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TABLE OF CONTENTS.

LEADING ARTICLES:	Pages.
Macadam Streets, Surfaced with California Liquid Asphalt, as Constructed in the City of Redlands, Cal. (illustrated); C. C. Brown	365
Specifications for the Construction of Oiled-Graveled Streets, Los Angeles, Cal.	366
The Asphalt-Oiled and Tamper Roller Compressed Dirt Roads of Santa Monica, Cal. (illustrated)	366
The Utilization of Wood in the United States; R. S. Kellogg	367
Special Types of Hull Construction for Cargo Steamers (illustrated)	368
Concrete Reinforcement for Irrigation Structures; F. W. Hanna	370
W. McLea Walbank: President, Canadian Society of Civil Engineers (illustrated); J. A. Jamieson, M. Can. Soc. C. E.; M. Am. Soc. C. E.	371
Irrigation and Railways in India	371
Maximum-Live-Load Bending Moments and Shears for Bridges Carrying Electric Cars (illustrated); Frank P. McKibben, M. Am. Soc. C. E.	372
Transverse Contours for Roadway Pavements (illustrated)	373
Boiler Scale in Relation to Heat Transmission in Boiler Tubes	373
Experience with Steel Sheet Piling in Hard Soils (illustrated); Wm. G. Fargo.	374
Total Stream Discharge Diagram (illustrated); Harold Petterson	375
The Pacific Extension of the Mexican Central Ry. (illustrated)	376
A Center-Bearing Drawbridge with Pneumatic Raising Jack and Turning Engine (illustrated)	378
A Concrete Form Separator (illustrated)	379
The Use of Copper Sulphate at Pawtucket, R. I., to Prevent the Clogging of Sewage Filter Beds by Blanket Growth of Micro-organisms (illustrated)	379
Action of the Grand Jury on the New York Central Wreck at Woodlawn	386
A Report on Independent Motor Cars for Railway Service	387
Experience of English Railways with Automobile Coach Lines	387
Progress Report on the Water Supply at Bisbane, Queenstown	387
A Method of Constructing an Ellipse and Measuring the Curved Length (illustrated); Frederick R. Honey, Ph. B.	388
EDITORIAL	381
A Plan for Internal Waterway Improvement—Why Not Equip Locomotives with Speed Indicators?—Train Wreckers and High Train Speeds—The Result of 45 Miles an Hour on a 10° Curve—The Open Switch Disaster at Colton, Cal.—A Boom in Railway Signal Business—Our Disappearing Timber Supply—The Proper Field for Railway Motor Cars.	
Double-Tracking and Yard Improvements to Facilitate Freight Traffic on Railways	382
LETTERS TO THE EDITOR	384
Topography with an Abney Clinometer; V. S. Veazey—A Clinometer Graduated to Percentage of Grade; I. W. D.—Why Do Contractors Do Slipshod Work? John H. Ferguson—Locomotives on Curved Track; Edward Godfrey—A Rope-Drive Problem (illustrated); O. Grimm—Reinforced Concrete Floor Tests; W. J. Douglas—Examination for Chief of Bureau of Water, Philadelphia; Cassius E. Gillette—Engineer's Estimates for Partial Payments; V. P. Strange—Tables for Roadmasters (illustrated); W. W. Gaffin—Diagrams for the Design and Analysis of Reinforced-Concrete Beams (illustrated); W. H. Kniskern—The Hatchet Planimeter and "Tractrigraph" (illustrated); H. Prytz.	
ENGINEERING NEWS OF THE WEEK	388
PERSONALS	390
ENGINEERING SOCIETIES	390

MACADAM STREETS, SURFACED WITH CALIFORNIA LIQUID ASPHALT, AS CONSTRUCTED IN THE CITY OF REDLANDS, CAL.

By C. C. BROWN.*

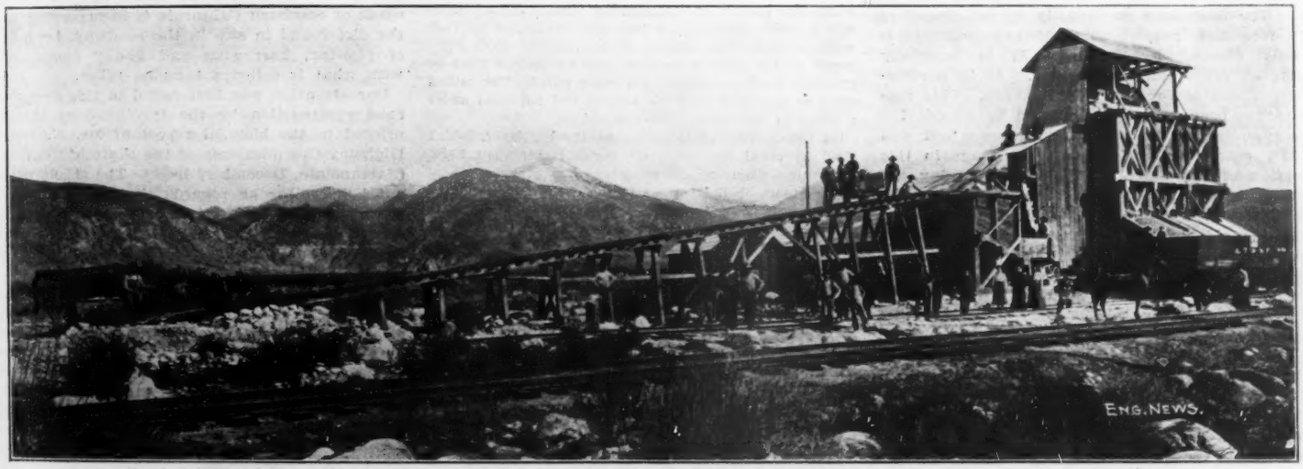
Redlands is a residence city embracing about 15 square miles, built mostly on steep slopes. The most of the soil is a red clay, very sticky when wet, but a good foundation if kept dry. The streets are well protected by a system of storm drains and granite border gutters. Asphalt pavement is used satisfactorily in the business section, but the cost is not within reach of the scattered residence districts, besides which the grades are too steep for this class of pavement. Ordinary macadam is not practicable by reason of the dryness of the climate, the cost of maintenance being prohibitory, to say nothing of the inconvenience of constant sprinkling. Surfacing with California crude oil was introduced in 1900 and has been continued ever since. It has been a success as a dust preventive, but it ruts easily and buckles worse than common clay. Two years ago experiments were made by spiking up the old oil cake surface, regrading, rolling down, treating with a heavy grade of liquid asphalt, and finally covering with a sharp river sand. This process has resulted in a good street surface for ordinary driving, but is not sufficiently durable for the main thoroughfares. In the year 1906 arrangements were made for the construction of over 20 miles of macadam streets surfaced with liquid asphalt. This improvement involved the expenditure of $225,000. A few streets are macadamized from gutter to gutter, but generally the central 20 ft., only, is macadamized, the borders being treated with the same liquid as the macadam.

*City Engineer, Redlands, Cal.

The material used for the crushed rock is very hard metamorphic granite boulders, having no cementicious qualities. It is spread on in two layers, the bottom rock running from 3 to 1½ ins. in size, and the top from 1½ to ¾-ins. It is then filled with screenings of the same material as the rock. The foundation and each course are thoroughly rolled, water being freely used while the screenings are being rolled. No excess of screenings is allowed on top, but all the interstices are filled, the water filling the capillaries. As soon as the water dries out the liquid asphalt is applied to take its place. The temperature of the asphalt must not be less than 150° F., the gravity not less than 10 and not more than 12° Baumé and must contain not less than 75% liquid asphalt. The amount used varies according to the nature of the rock and screenings, but there must be sufficient to fill all the voids. A light sprinkling of granite dust is the final step. This is continued until the liquid asphalt ceases to appear on the surface. The specifications call for not less than 1½ gals. per sq. yd., but in practice it generally requires 2 gals., or even more. Any excess that penetrates into the rock is all right, but an excess on the surface is a detriment. Excavations of this work several months old show the penetration to be from one-half to two-thirds way down into the rock. As soon as the work is complete the street is open to traffic.

Those streets having the greatest amount of traffic have turned out best. It requires several weeks of warm, dry weather with constant traffic to secure a good, smooth wearing surface. Heavy grade asphalts with a light percentage of volatile oils and sediments are more quickly seasoned than the lighter grade. Quite frequently in the summer months our temperature runs from 105 to 109° F. in the shade in the middle of the day. Under these conditions the new work becomes somewhat plastic, but not soft enough to disintegrate. These extreme weather conditions seem the most favorable for securing a good, permanent wearing surface. If any ruts appear ½ to 1-in. binder rock of the same material as the macadam is put on the surface and treated with the liquid asphalt. In a few days it unites with the surface material and soon it becomes thoroughly incorporated and there is no trace of the patching. Pipe trenches are repaired in the same way, and if the trenching is properly settled a perfect bond can be secured on the surface.

The liquid asphalt is applied from a wagon tank (Fig. 1) hauled by four horses or mules. It is forced out by gravity through a series of openings 4 ins. apart in a cylinder placed close to the ground, the flow being nicely controlled by a set of levers manipulated by a man on the rear of the wagon, who regulates the flow according to the speed of the team. It is very important to have an equal distribution. Patent distributors can be put on any suitable wagon tank at a cost of about $200. Two men and four horses can distribute, at an average haul of two miles each way, four tanks or 3,200 gals. per eight-hour day. The heating is done at the unloading tank by steam, which is also used to facilitate unloading the tank car. The cost fluctuates, but is generally about $1 per 40-gal. bbl., including $0.326 per bbl. for freight. There is a small amount of crude oil on the market that meets the requirements of our specifications. The most of the product used here is from the Los Angeles field and has had the volatile oils removed by extraction of distillates, the distillation being cut off at the proper point to meet the requirements of the specifications.



A MUNICIPAL ROCK CRUSHING AND SCREENING PLANT FOR STREET MACADAM MATERIAL, REDLANDS, CAL.
(Located in the Santa Ana River Wash, on the Santa Fe R. R., five miles northeast of Redlands.)

ruary, 1907 (after the date of the report already mentioned), are as follows:

(1) Contractor shall use the tamping roller approved by the superintendent of streets and board of trustees of the City of Santa Monica for all work under these specifications.

(2) The street shall be plowed to a depth of 6 ins. and graded evenly with a crown to conform to the established height at center of street, and properly pulverized with said tamping roller, said tamping roller shall be weighted from two to three tons, and to form a solid base up to 4 ins. from top.

(3) Where there is no cement or paved gutter, then the gutter 3 ft. wide out from curb shall be done in the following manner: Remove the earth 6 ins. deep below finished grade by the use of a grading machine, leaving earth to be removed in the street, then loosen bottom, lightly apply water, sufficiently, then apply 1½ gals. of oil to each square yard of surface, evenly; refill 3 ins. of loose earth, and water sufficient; tamp this evenly and solid, by using a wagon or truck with 4-in. width of tire weighted sufficiently to make a solid base; then back fill to grade. Gutters at street intersections as indicated by plans shall be of double width and constructed as hereinbefore mentioned.

(4) When the street is properly graded, pulverized and tamped solid to within 4 ins. from the top then apply water sufficient to thoroughly and evenly dampen to a proper consistency, 4 ins. deep, loosen with a cultivator lightly set so as not to disturb sub-base, then the oil shall be applied as follows: The street shall be coated evenly with oil at the rate of three-fourths of the amount to be used, then plow the oil under 4 ins. deep with a gang plow, commencing at center of street; then harrow diagonally two ways and then tamp with tamping roller weighted to penetrate 4 ins. evenly and solid to within 1½ ins. of the top; then run a road grader or scarifier over entire surface lightly to make the street an even grade; then harrow and apply sufficient water; then apply the second coat of one-fourth of the amount of oil to be used, evenly spread over entire surface of street; then harrow and tamp with tamping roller evenly and solid to top; then tamp gutters 18 ins. wide out from curb with a wagon or truck weighted with four tons as hereinbefore specified. The work and material under this section to be done the full width of the street and over the oil base of gutters as specified in Section 3 of these specifications.

Wherever upon any street or alley, any cement crosswalks, cement gutters, or any paving and machine work is impracticable then the same shall be done in same manner by hand work under the direction of the superintendent of streets.

The contractor will be held responsible for all damages to curbs, gutters, crosswalks, flumes, etc., that may be caused by him in the performance of the work. When water or oil is to be applied the condition of the soil shall be subject to the approval of the superintendent of streets. The contractor shall be required to examine all plans for the above work on file in the office of the city engineer.

(5) The quantity of crude oil to be applied to be 2½ gals. to every square yard of surface of heavy soil and 3 gals. for every square yard of light sandy soil, unless otherwise specified, from curb to curb, where there is no gutter, and where there are cement or paved gutters, then from gutter to gutter and at all intersection of streets and alleys to property line on both sides.

(6) The oil shall be from 12 to 14° gravity. Baumé test, at a temperature of 60° F., and contain not less than 70% of pure liquid asphaltum, natural non-processed oil, to be subject to the gasoline test for water and foreign matter, and not to contain over 2% of water or foreign matter, and heated to a temperature sufficient to run freely from a sprinkler or tank; provided, however, that in dry or dusty soil, 20 gals. of water must be used every 9 sq. ft. of road surface before applying the oil. The contractor shall provide an analysis of oil furnished when called for by the street superintendent.

(7) To insure the quality and quantity of all oil used under these specifications, the contractor shall deliver said oil into the city's tanks at the corporation yard, there to be tested for gravity, water, and foreign substance, by the street superintendent or his assistant, whose duty it shall be, after said tests are made, to heat, measure, and deliver said oil into such tank wagons as may be used to deliver and spread the oil on the street, and oil so handled at city tanks, shall be subject to a charge of — cts. per bbl., said charge to be paid by the contractor to the City of Santa Monica. A complete record of all these transactions shall be kept by the street superintendent.

(8) All work shall be, in every respect, executed in a thorough and workmanlike manner, and shall be prosecuted and performed in sections, each section to be two blocks in length; provided, however, that whenever there is a street railroad operated and maintained upon any section, said work shall be so prosecuted and performed as not to interfere with the maintenance and operation of said track or tracks during the progress of said work.

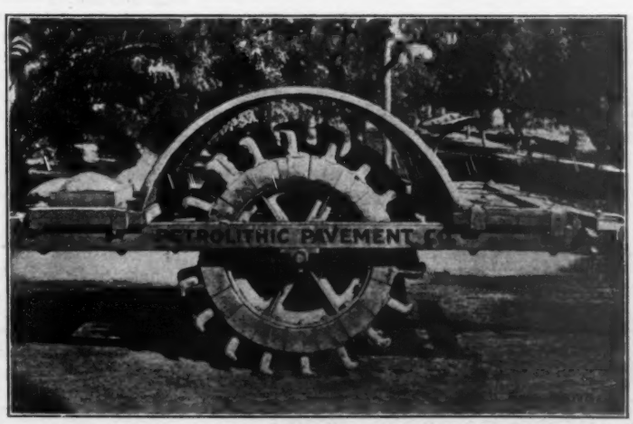
(9) The contractor shall erect a fence and keep erected a proper barrier along the line of said work and across the ends of same both day and night, and maintain red lights between sunset and sunrise and post all legal notices and signals as to the state of the roadway or street during the prosecution of the work.

Reference is hereby made to the general specifications now in force for the grading of streets within the City of Santa Monica, including all ordinances, etc.

(10) The work shall be performed under the supervision of the city engineer and street superintendent. Also subject to the approval of the Board of Trustees of the City of Santa Monica, or their authorized agents.—[Thos. H. James, City Engineer, Santa Monica, Cal., February, 1907.]

From printed matter sent by Mr. James, it appears that this system of oiled roads has been used on a boulevard near Los Angeles, extending from the Soldiers' Home toward the ocean north of Santa Monica. The boulevard is 130 ft. wide, with car tracks in the center. The portion of the boulevard treated was 56 ft. in width and extended for a length of 18,000 ft. At Monrovia, Cal., 15 miles of oiled streets are in use and 10 are to be added. How closely these roads conform in mode of construction to those at Santa Monica we cannot say, but the inference from Mr. James' letter is that they are similar. From a statement regarding the Monrovia roads sent by Mr. James, we learn that the specifications in use there have been gradually evolved by City Engineer J. H. McClymonds. The method differs widely from that generally employed elsewhere, in that it involves the use of a great deal of water, the roads being thoroughly soaked before the oil is applied, and again while the work is in progress. The finished highway looks like asphalt and often is mistaken for it. It is almost as hard and will endure for years under the heaviest travel.

The Fitzgerald tamping roller is controlled by the Petrolithic Pavement Co., 232 Pacific Electric Building, Los Angeles, Cal.



FITZGERALD TAMPING ROLLER FOR CONSTRUCTING ASPHALTIC-OIL DIRT ROADS.

THE UTILIZATION OF WOOD IN THE UNITED STATES.*

By R. S. KELLOGG.†

Our stumpage fit for the saw is rapidly decreasing. Our estimated forest area is 500 million acres, of which nearly 80% is in private hands, and will largely remain so. The best-managed German forests grow on an average about 50 cu. ft. of wood per acre annually. If our forests grew as well, they would barely furnish by annual growth the amount of wood we now use. It is probably safe to say that, under present conditions, the annual growth is not more than 20% that of the German forests. We are rapidly using up our forest capital. Pending the creation of a new wood supply by forest management and planting, we must solve the following problems in order to make our present supply go as far as possible.

REDUCTION OF WASTE IN MANUFACTURE.—According to present practice but little more than 25% of the cubic contents of a tree reaches the consumer in the form of lumber. This would not be important were the other 75% made to serve some useful purpose, but so far this has not been the case. The guiding principle for the future must be that every part of a tree is intrinsically capable of utilization.

Logging will be done more carefully, stumps will be cut lower, and tops higher. There will be greater care in cutting up the tree, and log lengths will be adapted to the peculiarities of the tree, rather than being arbitrarily fixed. Logs, tops, and stumps will all be used eventually; probably for fuel, excelsior, distillation, or pulp, depending upon the locality and species. Needless to say, thousands of feet of logs will not be used for temporary roads, slides, and skidways, and then left to rot in the woods. Neither will any tree be left to decay simply because it is crooked or of an inferior species.

Manufacturing will be more economical. The bandsaw has now largely replaced the circular saw, and it will do so more in the future. This alone means a great saving in saw kerf. Logs will be slabbed more carefully. There is a saving in slabbing a log on four sides instead of on only two sides before cutting it up, but this is not always done. Slabs will be more closely utilized, and even now, the best-managed northern mills find it profitable to run their white pine and hemlock slabs through a horizontal band re-saw, and so obtain one or two additional narrow boards. There will be less waste at the edger and trimmer. There is little reason for making only even lengths and widths in the stock grades of lumber, aside from large dimension stuff, and it is pure nonsense to cut 2 ft. from a board because a knot is within 6 ins. of the end. The movement in favor of odd widths and lengths has made notable progress among lumber manufacturers in the last year.

We may expect that slabs, edgings, and trimmings will cease going into the burner, and instead be devoted to some useful and profitable purpose. Aside from the usual output of lath and shingles as by-products of lumber manufacture with certain species, we may expect to see some of the present waste converted into small dimension stuff, box boards, crate sticks, and other articles, with always a possibility of conversion into pulp or wood-distillation products. So long as the sawdust feeds the mill furnaces, it may be considered satisfactorily utilized. A comparatively recent departure in lumber manufacture that is rapidly gaining ground is the production of veneer stock. This is a most economical method of cutting up a log, particularly if done by the rotary process, since there is no loss whatever in sawdust, and the cores can be used for crate sticks, box boards, pulp, fuel, or other purposes. Veneering makes the same quantity of material go much further than it would if sawed in the ordinary manner, and the weakening of the demand for quarter-sawed oak lumber is directly chargeable to the increased use of veneer stock.

Lumber will be handled more carefully in the yard, and less exposed to injury by the elements. Methods of seasoning, both in the air and in the kiln, will be improved, and loss through warping and checking will be reduced.

ECONOMIES IN THE USE OF WOOD.—We are using annually over 400 ft. B. M. of lumber per capita, while Europe averages but 60. We can and must learn to use less and use it more judiciously. A great gain is now going on in the use of steel, cement and concrete. A cement block house now costs but little more than a wooden one, and in a few years it will be the cheaper. Reinforced concrete is used for piles, bridges, warehouses, etc. The highest type of modern office buildings are constructed almost entirely of steel, brick, and other artificial material. Cement walks in towns are replacing wooden ones with decided gain in utility. The production of Portland cement in the United States has increased 400% in the last six years.

We can learn to use one fence-post, one cross-tie, one mine timber, and one telephone pole where we now use two, and still have the same or a greater amount of service. This is possible through the prolonged life obtained by preservative treatment. The saving in timber along this line will reach into millions yearly.

It is estimated that nearly 10% of the annual lumber cut of the United States goes into packing boxes, and in fact, 80% of the white pine cut in New England is so used. Yet the life of the packing box is remarkably short, and after serving its initial purpose it is cast into the rubbish heap. Much can be saved along this line. Mechanical tests upon all the principal woods, to determine their strength, stiffness, and other physical properties, and the effect of knots, checks, and other defects upon commercial sizes, will give the proper

*From a paper read before the Western Society of Engineers, Chicago, Feb. 20, 1907.

†Forest Inspector, U. S. Forest Service, Washington, D. C.

Six miles in length, or about 100,000 sq. yds., of our work has been completed. An unusual amount of rainy weather for the past two months has been a good test for the new work. It stands up all right. The firmness of the surface has exceeded all expectations. There are some sections having small depressions due to the settling of pipe trenches and to defective work, all of which can easily be repaired. The finished work when fully seasoned closely resembles that of asphalt paving. It is not so smooth on the surface. Horses' hoofs do not clatter nor slip on it. The dust does not readily fly off, therefore it does not require constant sweeping. It is easily cleaned by flushing. It is especially adapted for residence districts. It is particularly desirable for easy maintenance. This feature has been fully demonstrated by resurfacing many miles of the old, partially worn out and badly rutted lime rock macadam roads in this portion of the State until they are to-day the finest roads in the country. Decomposed granite or limestone screenings have been used mostly for this old work. We have used granite because it was available. The lime rock used in this section has given quicker results but not as firm a surface as the granite.

FIG. 1. TANK WAGON, WITH GLOVER DISTRIBUTOR FOR SPREADING LIQUID ASPHALT FOR GRANITE-ASPHALT FINISH TO MACADAMIZED STREETS, REDLANDS, CAL.

It requires 1¼ cu. yds. of rock on an average, as measured in the Otis railroad dump cars after a five-mile haul by rail, to make 1 cu. yd. of finished work, including the sand and asphalt. The city owns and operates the crushing plant which delivers the rock into dump bins at the depot, in which all shoveling is eliminated, and sells it to the contractor for $1 per ton. The cost of the work on this basis for an average wagon haul not exceeding one mile has been 6 cts. per sq. ft., not including the incidental expenses, which add about ½-ct. to this amount. The beginning of this work was somewhat experimental with all of the contractors, but they have it well programmed now so that the coming season we expect much better and more rapid work than that which has heretofore been done.

SPECIFICATIONS FOR THE CONSTRUCTION OF OILED-GRAVELED STREETS, LOS ANGELES, CAL.

The biennial report (dated December, 1906) of Mr. N. Ellery, Commissioner of the Department of Highways, California, contains specifications used at Los Angeles, Cal., for the construction of oiled-graveled streets. A large part of these specifications is reprinted below. The portion omitted relates chiefly to grading. Those sections provide that after the subsurface of the roadway has been brought to grade it must be rolled with a roller weighing not less than 250 lbs. per sq. in. of width of tire. The specifications for placing the gravel and for treating it with oil, including the requirements for the oil, are as follows:

Upon the surface, prepared and brought to sub-grade in the manner above specified, shall be spread in the following described manner: Two layers of good gravel, the bottom layer to have a thickness of 5 ins. and the top layer to have a thickness of 3 ins., after having been rolled. The first layer, which shall contain no stones larger than 2½ ins. in greatest diameter, is to be uniformly spread on the roadway, and well moistened. The gravel shall be well rammed for at least 1 ft. from the gutters, should these be paved, or if the gutters are not paved, then 1 ft. from the curb. The remaining portion of the roadway shall then be rolled with a roller, weighing not less than 250 lbs. to the inch width of tire. The rolling of the roadway shall commence at the rammed portion. All depressions must be promptly filled, moistened, and again rolled. The rolling must be continued until the surface will not yield under a roller of the weight above described.

On this surface shall be spread the top layer, which shall be raked free from all stones larger than 1 in. in greatest diameter. If no gutters are provided, these larger stones shall be raked to the curb and distributed over a strip 2 ft. in width next to the curb. If gutters are provided, then these stones shall be distributed on a strip 2 ft. in width next to the gutter. The top layer of gravel shall then be thoroughly compacted by ramming and rolling in the same manner as specified for the first layer.

Oil shall then be evenly distributed over the entire surface of the roadway in a volume equal to ½-gal., by measure, per sq. yd. of the street surface.

Clean, sharp sand shall be sprinkled over the entire surface of the roadway until no oil or the residue thereof can be seen.

After a lapse of not less than 12 hours, oil shall again be evenly distributed over the entire surface of the roadway in a volume equal to ½-gal., by measure, per sq. yd. of the street surface.

The entire surface of the roadway shall again be sprinkled with clean, sharp sand until the oil and the residue thereof is completely absorbed, and then rolled with a roller weighing not less than 250 lbs. to the in. width of tire until the surface is unyielding.

The total amount of oil used shall not be less than 1 gal. per sq. yd. of the street surface. The oil shall be applied at a temperature not less than 150° F.

The oil used shall be crude petroleum, and shall answer to the following tests, to wit:

(a) *Specific Gravity.* The specific gravity shall not be lower than 10° nor higher than 11° Baumé.

(b) *Test for Specific Gravity.* All crude petroleum shall be tested for specific gravity, and the gravity thereof shall be determined by the use of "The Westphal Specific Gravity Balance," in conjunction with the accepted scale, hereinafter described, for addition and deduction below or above normal temperature.

(c) *Temperature.* All crude petroleum shall be delivered ready for sprinkling at a temperature of not lower than 150° F. or above 190° F., and in determining the quantity of petroleum delivered, the correction and expansion by heat shall be as follows: In all crude petroleum received at any temperature above 60° F. an amount equivalent to 0.4 of 1% for every 10° F. shall be subtracted from the observed volume as the correction for expansion by heat. For the purpose of measuring crude petroleum a temperature of 60° shall be deemed normal temperature.

(d) *Asphalt.* All crude petroleum shall contain not less than 70% "D" grade asphalt, California standard.

(e) *Test for Asphalt.* The sample of oil shall be placed in an evaporating dish and heated in a hot-air oven at 400° F. until it is reduced to "D" grade asphalt, California standard. The residue is weighed and the per cent. of asphalt calculated.

(f) *Water and Sediment.* All crude petroleum shall be tested for water and sediment.

(g) *Test for Water and Sediment.* The "gasoline test" shall be used to determine the amount of water and sediment. Said test shall consist of equal parts crude petroleum and 68° Baumé gasoline, mixed in a glass-stoppered glass cylinder and left to stand 12 hours; thereupon reading shall be taken and the percentage of water and sediment determined.

(h) *Deductions.* Deductions for water and sediment in crude petroleum will be made in exact proportion to the percentage of such water and sediment found. Deductions for shortage in volume will be made in the exact number of gallons tank wagons are found to be short on delivery.

(i) *Tank Wagons.* All tank wagons used for delivering the crude petroleum must first be submitted to the street superintendent, who shall gage and stamp into the steel head of said tanks the capacity in gallons said tanks will contain, and no figures of capacity will be accepted other than the official rating given by the street superintendent.

(j) All oil to be used shall be tested by an oil inspector employed by the street superintendent for that purpose.

(k) Oil shall be tested at tanks before delivery upon work, and if same shall not comply with specifications, it shall not be delivered at the work.

THE ASPHALTIC-OILED AND TAMPER-ROLLER COMPRESSED DIRT ROADS OF SANTA MONICA, CAL.

A unique system of constructing oiled dirt roads is in use at Santa Monica, Cal., and appears to have been adopted elsewhere in that vicinity. In this system of construction the heavy asphaltic oil used with so much success on the roads of Southern California is incorporated with the dirt found in site in the roadway, by means of plowing, harrowing and finally compressing with what is called a tamping roller.

Our attention was first called to this system of road construction by the specifications therefor printed in the biennial report of Mr. N. Ellery, Highway Commissioner of the State of California (Sacramento, December, 1906.) The specifications not being clear as regards the roller, owing to the absence of a description thereof, application was made to Mr. Thomas H. James, City Engineer of Santa Monica, for information regarding the roller and roads constructed with it.

Mr. James states that "the oiled paving process is known as the Santa Monica system," since it originated and was perfected by experiments in that city. The roller used in the work is known as the Fitzgerald tamping roller, and "has proven to be a great success for mixing and bonding the soil and oil until it becomes almost like an asphaltum pavement." At the inception of the "oiled paving process" in Santa Monica, the city leased the tamping roller to the contractors at the rate of $10 per block, or about 1½ cts. per lin. ft. At the present time many of the contractors own tamping rollers. During the past few years about 20 miles of "oiled paved" streets have been constructed in Santa Monica. Even after severe rain storms these roadways and boulevards are in good condition, including those on 1 to 3% grades. Some of the roadways have been subjected to heavy team and truck loads without injury, many of the heavy wagons having narrow tires.

Mr. James states that although he has had no practical experience with the effect of frost upon these roads, yet he thinks frost would not penetrate them if the oil was worked down to a depth of 8 or 10 ins. below the surface.

Regarding the cost of the roads treated by this system, Mr. James says:

> The average cost per square foot of the oil-paved roadways is from 1¾ to 2¾ cts., providing that in preparing the roadway surfaces the cuts or fills do not exceed 1 ft. Hence our oiled-paved dustless residence streets cost about 1-10 the price of a first-class asphaltum pavement, of about ⅛ the cost of concrete and paving brick.

The specifications, as slightly amended in Feb-

with in the turret-deck steamer "Grangesberg," which can discharge the cargo (coal or ore) with its own machinery in 34 hours, and has done it in 27 hours, being fitted with cargo handling equipment of a very elaborate character for rapid unloading. This vessel is shown in Fig. 4; it is 455 ft. long, 62 ft. wide and 30 ft. 3 ins. deep, carrying 11,000 tons on a draft of 22 ft. 3 ins.; hold capacity, 570,000 cu. ft.; British net tonnage, 4,250 tons. It has triple-expansion engines of 2,300 HP., giving an average sea speed of 10 knots. Along the upper part of the side will be noticed pivoted triangular frames which can be swung out to carry gangways to the dock or pier.

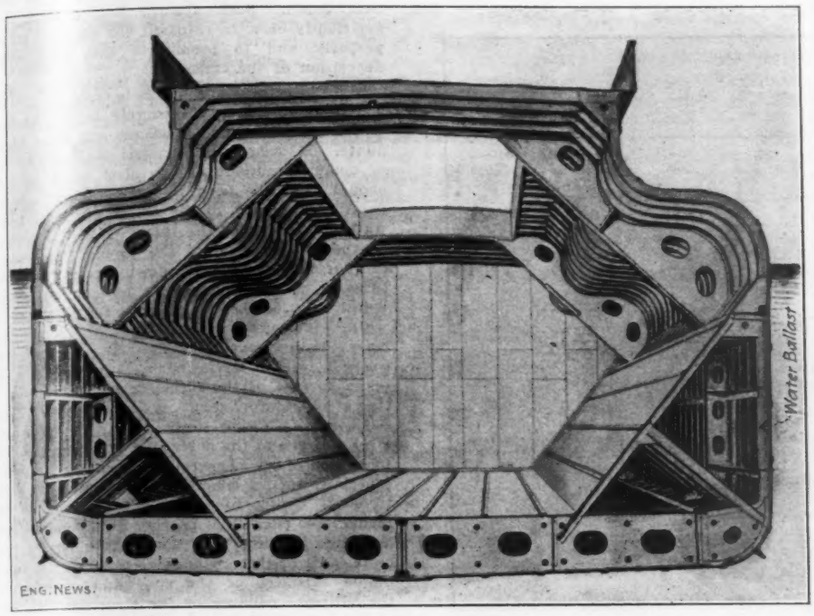


FIG. 3. STEAMER OF THE TURRET-DECK TYPE, WITH SELF-CLEARING HOLD FOR BULK CARGO HANDLED BY GRAB BUCKETS.

In Fig. 5 is shown a view of the steamer "Poplar Branch," one of two built for the Nautilus Steamship Co.; it has a shelter deck on top of the turret section, and the machinery is placed amidships as in ordinary ocean steamers. This view gives a very good idea of the peculiar form of hull, with the "harbor deck" construction. These are tramp steamers with a cargo storage capacity of no less than 70 cu. ft. to the ton, enabling them to deal with the lightest cargo at the minimum rates. They have side masts or derrick posts, as in the "Grangesberg." These steamers are 414 ft. long, 56 ft. beam and 29 ft. deep, with a dead weight of 8,800 tons on a draft of 23 ft. 6 ins.; hold capacity, 587,000 cu. ft.; British net tonnage, 7,460 tons. They have triple expansion engines of 2,250 HP., giving an average sea speed of 10½ knots. In American service there is the turret-deck steamer "E. O. Saltmarsh," of the Louisville & Nashville R. R., running in the coal trade between Pensacola, Fla., and Tampico, Mex.; with the Doxford system of derrick gear it regularly discharges 2,400 tons per day from five hatches, delivering the coal into cars 6 ft. from the edge of the wharf or pier. Both of the vessels illustrated are in ballast and consequently high out of the water.

These turret-deck steamers are built by William Doxford & Sons, of Sunderland, England, and to them we are indebted for photographs and other information. There are over 150 of these steamers in service, and the builders now build only this class of vessel. One steamship line alone, the Clan Line, operates 30 of these steamers in its service between British and Indian ports, with round-trip voyages of 25,000 miles. The British India Steam Navigation Co. also has several steamers of this type in use in the Indian coal trade. The builders turned out 20 of these steamers in 1905 and 25 in 1906, the aggregate gross tonnage being 86,632 tons and 106,058 tons, respectively.

Another special type of hull construction is that of the Harroway & Dixon system, which is patented in this country, as well as in Europe, and is claimed to be peculiarly adapted to the large ore and freight steamers employed on the Great Lakes. In this design, which is shown in Fig. 6, cantilever frames are used, and the hold is entirely unobstructed by pillars, beams or webs. Longitudinal plate girders carry the inner ends of the frames and of the deck beams, and between the longitudinal girders are heavy transverse beams spanning the hatchway opening; some of these are portable and can be lifted out by the cargo derricks to give great length of hatchway in handling such cargo as steel rails, timber, etc., or to facilitate the working of grab buckets in unloading bulk cargo (coal, ore or grain). The hatchways are also exceptionally wide, and the form of the hold is such as to be self-trimming with coal or grain. The triangular space on each side, between the sloping backs of the frames and the skin plating, is utilized as a top-side water-ballast tank, thus giving water ballast capacity 75% greater than when only the usual water bottom tanks are used. In this way the propeller is given a good depth of submersion when the ship is in ballast.

In steamers for cargo service alone there is no upper deck, but in vessels with passenger or cattle accommodation there is an upper or shelter deck, as shown in Fig. 6. The tonnage is low in comparison with the cargo capacity, especially as the water-ballast tanks are not included in the tonnage measurement; the hold capacity is over 50 cu. ft. per ton of dead weight. The engines are sometimes placed amidships and sometimes at the extreme stern, according to the service and cargo for which the vessel is designed. For bulk cargo, side masts or derrick posts (in pairs) are used, each having two booms, so as to be entirely independent of unloading plant at the ports. In this country, however, and especially for the traffic on the Great Lakes, the development has been in the way of providing unloading machinery at the piers rather than on the steamers.

These cantilever-frame steamers are built by Sir Rayiton Dixon & Co., of Middlesbrough, England, who are the owners of the patents. One of the larger vessels has a dead weight of 7,500 tons on 23 ft. draft, with a net registered tonnage of 2,500 tons, and capacity for 2,200 tons of water ballast. The dimensions of another large steamer are as follows: Length, 370 ft.; beam, 52 ft. 3 ins.; depth, 28 ft. 4 ins.; dead weight, 8,000 tons; draft, 24 ft. 6 ins.; net tonnage, 2,600 tons; gross tonnage, 4,030 tons; water ballast, 2,200 tons. The cubic capacity (exclusive of coal bunkers) is 448,000 cu. ft., or 56 cu. ft. per ton of dead weight.

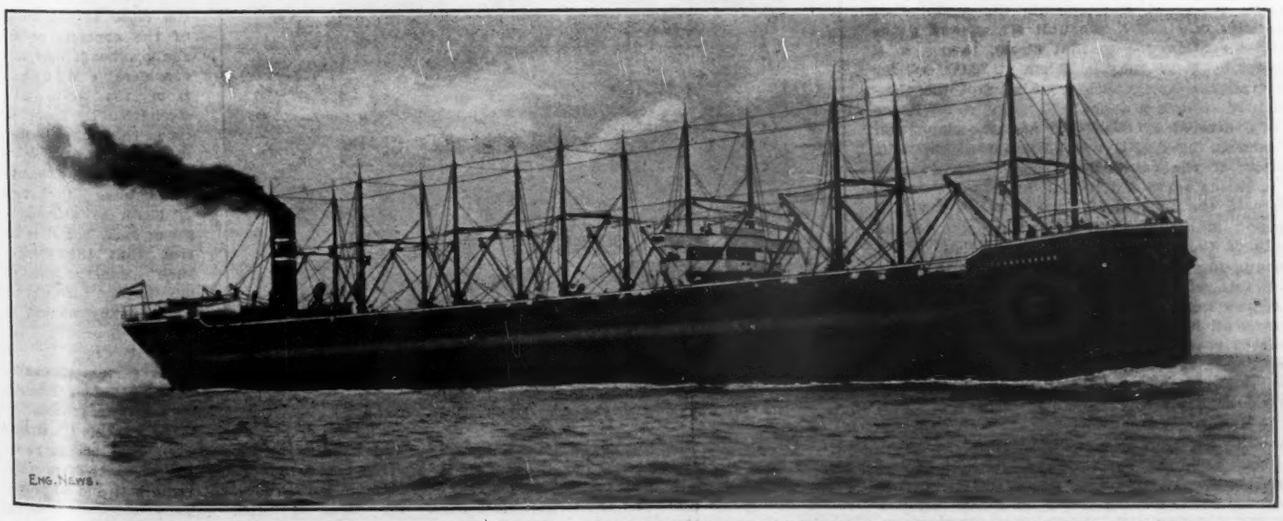


FIG. 4. OCEAN-GOING ORE STEAMER "GRANGESBERG," OF THE TURRET-DECK TYPE (WITH CARGO-DISCHARGING EQUIPMENT).
Wm. Doxford & Sons, Sunderland, England, Builders.

basis for grading rules and indicate clearly the kind and quantity of material needed for a given use.

SUBSTITUTION OF OTHER WOODS.—Woods which have long been considered inferior or useless will be utilized and in many cases substituted for those which are getting scarce. The evolution of the wagon box is an excellent example. Once, the standard box board was white pine, then came yellow poplar, then cottonwood, more recently red gum, and to-day the formerly despised tupelo is going into wagon boxes (though surreptitiously); to-morrow it will hold an honored place. Each of these changes has come about as a result of the decreasing supply and increasing price of the wood formerly used. Similarly, axles are being made of maple instead of hickory, and implement poles of long leaf pine instead of oak.

Though it does not seem at present possible to get anything as satisfactory as hickory for buggy parts, elm for slack barrel staves and hoops, and white oak for tight cooperage, there is a great field of possible substitution, since so little is really known of the essential properties of most American woods.

SPECIAL TYPES OF HULL CONSTRUCTION FOR CARGO STEAMERS.

The enormous amount of ore-carrying traffic on the Great Lakes has led to the introduction of large steamers with hulls specially designed for light weight combined with great carrying capacity and great facility of unloading. It is not so generally known that extensive progress on similar lines has been made in England in the design of ocean-going cargo steamers for general or special classes of freight. During a visit to Europe last year a member of the editorial staff of Engineering News saw a number of these steamers in British ports and at Antwerp, and obtained some particulars as to their construction.

Foremost among these special types of steamers are those of the "turret-deck" type, invented by Mr. Charles Doxford some twelve years ago. Since that time several improvements have been made in the general design, and these steamers have for several years been working on various trade routes. The object of the design was to reduce the weight of material in the hull without reducing the strength, every ton thus saved adding a ton to the carrying capacity. This object is partly attained by the extensive use of flanged or joggled plates, which form longitudinal ribs or flanges, while by this method of construction the use of packing strips or fillers at the joints of the plates is eliminated, with a consequent material reduction in weight. The plates of alternate rows in the sides and bottom have the edges offset or "joggled" so as to lap over the edges of the other plates. At what would be the deck level of an ordinary steamer the sides are curved inward and upward, as shown in the accompanying views and cross sections, this upper portion forming a strong stiffening girder and giving a higher freeboard. It also helps to trim the cargo, and with such material as grain in bulk it forms a "head" to keep the hull filled solid and so prevent shifting of the cargo. Furthermore, it gives increased vertical bunker capacity, with the advantage of delivering coal to the boiler room by gravity.

There are no transverse bulkheads in the cargo space, and the continuous hatchway gives special facilities for loading timber and rails. In the latest designs of turret-deck steamers, all web frames and stringers are dispensed with, as well as interior pillars, thus giving a clear and unobstructed cargo hold, with no broken stowage, while considerable time is gained in loading and discharging cargo. There is also an unusually large water-ballast capacity. In the outer horizontal portion, termed the "harbor-deck" (but which an engineer might call a bench or berm), are cargo and bunker hatches, which greatly facilitate loading cargo and coal. In some cases also a deck cargo of lumber is built up on this harbor deck to the height of the turret deck.

The builders claim that by this method of construction they obtain 58 to 60 cu. ft. space per ton of dead weight under hatches, as compared with 52 to 54 cu. ft. per ton in the ordinary type of steamer. With this reduction in weight, more cargo can be carried on a given draft or displacement, while the lower registered tonnage ensures a saving in charges based on tonnage. Thus the charges for passing through the Suez Canal are based on registered tonnage, and as many of the steamers are worked on canal routes they effect a material saving to their owners in these charges. These vessels are also more economical in the charges for trimming when loading coal or grain. Some of the turret-deck tramp steamers have a cargo stowage capacity of 70 cu. ft. to the ton of deadweight.

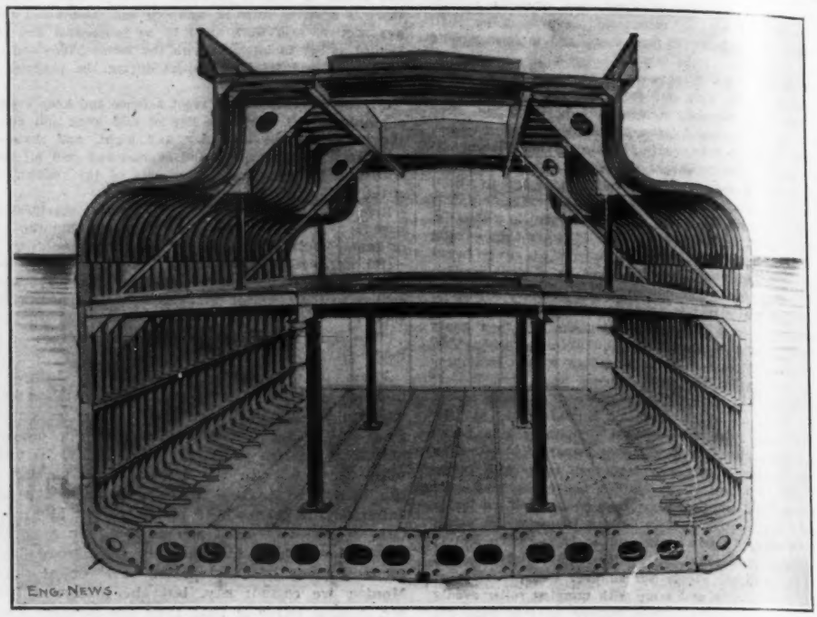


FIG. 2. STEAMER OF THE TURRET-DECK TYPE, WITH INTERMEDIATE DECK.

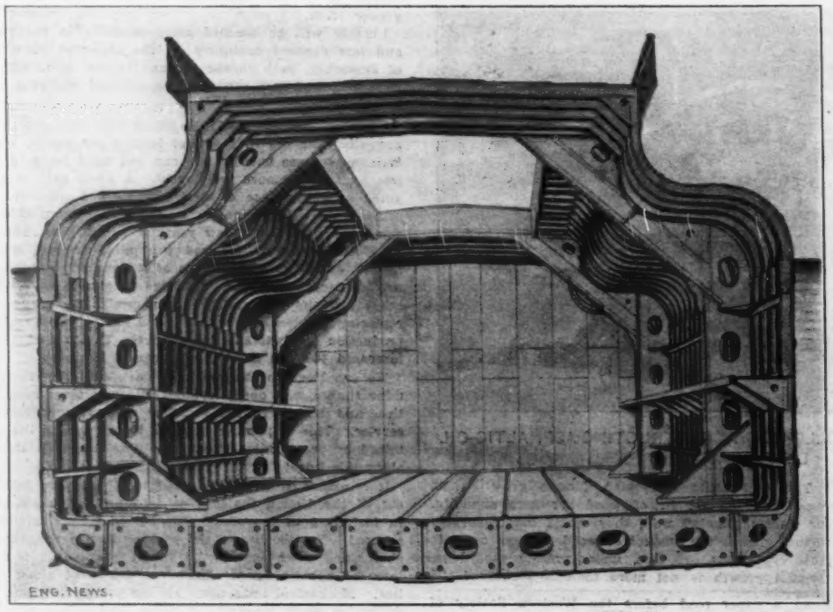


FIG. 1. STEAMER OF THE DOXFORD TURRET-DECK TYPE, WITH WEB FRAMES AND CLEAR HOLD.

The cross-section of hull, Fig. 1, shows a design for clear stowage and no intermediate decks; here the framing is reinforced at intervals by deep web frames with diagonal web frames to the upper deck, while wide shelf stringers run longitudinally inside the hull. The capacity of hold is 58 cu. ft. per ton of dead weight. Where it is desired to avoid the deep web frames, pillars are placed under the line of the sides of the turret deck, and diagonal beams from the sides to the deck, take the place of the diagonal web frames; the stringers are also entirely dispensed with. The section in Fig. 2 represents a design of hull used in ocean liners requiring intermediate decks for general cargo. The hull section shown in Fig. 3 is a special design for bulk cargo or deadweight trades, such as coal, ore, and grain, which can be handled by grab buckets. The spaces behind the sloping sides of the hold are utilized as additional water ballast tanks, and the machinery is all placed at the stern, giving an unbroken hold from the engine-room to the collision bulkhead. This section is in general similar to that of some of the ore steamers on the Great Lakes. Some of the turret-deck steamers have six or seven pairs of side masts, each fitted with derrick booms, these taking the place of the ordinary central masts.

In regard to cargo handling facilities, it is noted that a few years ago W. H. Muller & Co., of Rotterdam, Holland, invited competition for an ore-carrying steamer requiring more than 10,000 tons dead weight with a draft limit of 22 ft. 3 ins., the length of cargo space to be limited to 354 ft., and the engines to be placed at the stern. The conditions necessitated abnormal dimensions and special design, but were complied

ing between reinforcing steel and concrete does not differ essentially in irrigation structures from that of the general practice in other classes of work, if it is assumed that water soaking does not decrease the bonding adhesion. Since the maximum unit working stress for reinforcing steel has been assumed herein at 15,000 lbs. per sq. in., ordinarily no mechanical bond will be required to insure reinforced concrete structures of the class under discussion against failure through insufficient bonding, when proper precautions are taken to provide sufficient anchorage beyond any point in a bar to develop its strength at that point. The mechanical bonding of reinforcing steel in such structures as pipes under hydraulic pressure is, however, of advantage, although the working stress in the steel may be comparatively small. Such structures usually suffer longitudinal cracks due to stretching of the steel beyond the tensile strength of the concrete. When smooth bars are used these cracks will be few and large, through concentration of the total stretch into a few places; when mechanical bonding bars are used such concentration is prevented and the cracks will be numerous and small.

If the soaking of reinforced concrete in water materially reduces the adhesion between the steel and the concrete, as the report of some experiments indicates, the use of a mechanical bond in reinforced concrete for practically all irrigation structures is imperative. Extended experiments on the effect of water soaking reinforced concrete with reference to bond would be a valuable addition to concrete data.

W. McLEA WALBANK: PRESIDENT, CANADIAN SOCIETY OF CIVIL ENGINEERS.

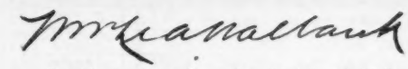
By J. A. JAMIESON,* M. Can. Soc. C. E.; M. Am. Soc. C. E.

W. McLea Walbank was born at St. Johns, Newfoundland, in November, 1856, and obtained his primary education in the schools of his native city. In 1873 he commenced an engineering course in Queen's University, Galway, Ireland, but owing to the death of his father, and removal of his mother to Montreal in 1874, he left Queen's and entered McGill University, taking the Civil and Mechanical Engineering course; he graduated from McGill in 1877, with the degree of B. A. Sc.

In 1878 he was admitted to practice as a Provincial Land Surveyor by the Board of Land Surveyors of the Province of Quebec. In the same year he opened an office in Montreal and subsequently succeeded in building up a large and profitable practice in engineering, surveying and architecture, carrying out many important works in the city, and in the surrounding municipalities and country generally. It was, however, chiefly in connection with hydro-electric development and distribution of electrical energy in the city and district of Montreal that Mr. Walbank firmly established his reputation for engineering skill, business foresight and executive ability. The most notable illustration of these qualities is found in his work in organizing a company to develop the power of the Lachine Rapids, and designing, constructing and successfully managing the plant.

A few miles west of Montreal on the St. Lawrence River is located the Lachine Rapids, over the tortuous rocks of which an immense volume of water passes at all seasons of the year. For more than a quarter of a century the utilization of this power had been under discussion, and many schemes had been suggested for its development into electrical energy. While the volume of water passing through the rapids was very great, consisting of the whole supply of the St. Lawrence and the greater part of the Ottawa River, not more than 12 ft. head could be obtained, and indeed this was often reduced to 8 ft. by back-water due to the jamming of the ice in the channel opposite Montreal. In addition, large volumes of "frazil" and floating ice are formed during the severe winter months, in the swift and open current extending approximately three miles above the rapids proper, which greatly increase the hydraulic difficulties. These prominent features had caused several eminent engineers to report adversely on a number of other schemes for the development of the power of these rapids. This, however, did not deter Mr. Walbank from boldly attacking the problem, which he eventually carried to a successful conclusion.

In 1891 Mr. Walbank made surveys and during the subsequent five years took observations and levels of the water, and at the same time, in association with Messrs. T. Pringle & Sons, hydraulic engineers, made preliminary plans and estimates for the development of a hydro-electric plant which convinced them that a commercially successful development was possible. In 1895 he organized the Lachine Rapids Hydraulic & Land Co. Owing chiefly to Mr. Walbank's strong personality and to the fact that himself and associated engineers displayed their full confidence in its success, by investing the greater part of their own capital in the enterprise, all necessary money for the complete development was subscribed within a few weeks by strong local capitalists. Complete plans and specifications were then prepared, and early in 1896 contracts were let for the work. Within eighteen months electrical energy was delivered within the limits of Montreal, and the new company became a strong competitor for the lighting and power supply of the city, proving a commercial success from the start. In view of the engineering and other difficulties that had to be overcome, this was an achievement worthy of note.



President of the Canadian Society of Civil Engineers.

Mr. Walbank was elected Managing Director of the Lachine Company on its organization, and retained this position until the total stock of the company was sold in 1903 to the Montreal Light, Heat & Power Company at a cash price of $190 per share. Mr. Walbank was subsequently offered, and accepted, the position of Vice-President and Chief Engineer of the last-named powerful company, which position he holds to-day. As Chief Engineer he takes entire charge of all the engineering work of the company. He has recently completed the reconstruction of the Chambly dam, and the construction of a new dam at St. Therese, on the Richelieu River. He has at present under construction on the Soulanges Canal, about 30 miles from Montreal, a hydro-electric plant which it is expected will produce 20,000 HP. during the winter season, when the canal is not required for navigation; also a large fireproof office-building in which will be located the general offices of the company in Montreal.

In 1883 Mr. Walbank was elected member of the Council and member of the Board of Examiners of the Provincial Land Surveyors Association, Province of Quebec. He was President of that body from 1887 to 1900.

Mr. Walbank is a charter member of the Canadian Society of Civil Engineers and has always taken a prominent part in the conduct of its affairs, being recognized as one of the most active and progressive members of the Society. He has several times been elected to a seat in the Council, and to membership on important committees. In 1906 he was elected one of the Vice-Presidents, and his election to the office of President for the present year is not only in the line of promotion, but a recognition of his career as an engineer and his untiring activity in promoting the best interests of the Society.

In the midst, however, of these varied enterprises in applied engineering, Mr. Walbank has not neglected his duties as citizen of the foremost city of the Dominion, for he has been a Justice of the Peace since 1885, and has taken an active part in public affairs, chiefly in looking after legislation affecting industry generally and the interests of the engineering profession in particular.

In 1888 he was married to Miss Richards, daughter of the Hon. Wm. Richards, of Prince Edward Island, and his well preserved physical condition shows that in the stress and strain of a professional and strenuous business life he has found compensating joys in the felicities of an ideal home circle.

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IRRIGATION AND RAILWAYS IN INDIA.

In a recent report on Trade Conditions in India, Mr. C. M. Pepper, Special Agent of the United States Department of Commerce and Labor, has some very interesting notes on irrigation and railways in India, from which the following has been condensed:

IRRIGATION.

There are now approximately 40,000,000 acres of irrigated land in India, of which 20,000,000 acres of canal irrigation are under state control in British India. The total length of the irrigation canals, which in 1891 was 9,000 miles, is approaching 50,000 miles. The section which contains the largest area is the Punjab—the region of the five rivers whose waters are tributary to the Indus. This section has now about 12,500,000 acres irrigated by productive works. The more recent ones have been for the construction and improvement of storage reservoirs, and the greatest of these is the Chenab barrage, or dam. Both the Chenab and the Jhelam rivers are harnessed and their floods controlled, diverted, and distributed by a complete system of canals. Other works under construction or in project relate to similar results on the Indus and the diversion into the western desert of waters that now flow futile to the Arabian Sea.

Irrigation works undertaken by the government have proven very good investments. In the last year for which returns have been reported the great Sidhani Canal earned nearly 20% on the capital outlay, the Lower Chenab 24%, and the Ganges canal 9½%. In southern India, in the Madras district, the net return was 9%. In other districts the earnings were small, but the entire system of irrigation canals, both productive and protective, netted 7½% in 1905.

In the future, productive irrigation works will receive less fostering aid from the state than in the past because, as it is claimed, they now cover or will soon cover all the area which is valuable for them. The promise is held out that more attention will be paid to protective works, absence of or indifference to which as a means of relief against steadily recurring famines has been much criticized.

The greatest of these works, and one which after a very long period of waiting has received official sanction, is that in the Bombay Deccan, known as the Godaveri canal project. This contemplates a masonry dam 82 ft. high and 5,700 ft. long, across the Darna River, a tributary of the Godaveri, so as to form a long lake in the river valley for storage purposes. It is intended to store 9,000,000 cu. ft. of water. Subsidiary to it are to be two canals, 50 and 75 miles long, respectively, and the waters of these canals are expected partially to relieve large regions which owing to insufficient rainfall suffer periodically from famine. The estimated cost of this project is about $3,250,000.

CONCRETE REINFORCEMENT FOR IRRIGATION STRUCTURES.

By F. W. HANNA.*

Owing to the more or less constant exposure of concrete irrigation structures to the effects of water, the principles governing the stress, size, spacing, placing, bending and bonding of reinforcing steel in the concrete are somewhat different from those of architectural practice. It is the object of this discussion to point out in a general way some of these differences, which though simple in theory are important in practice.

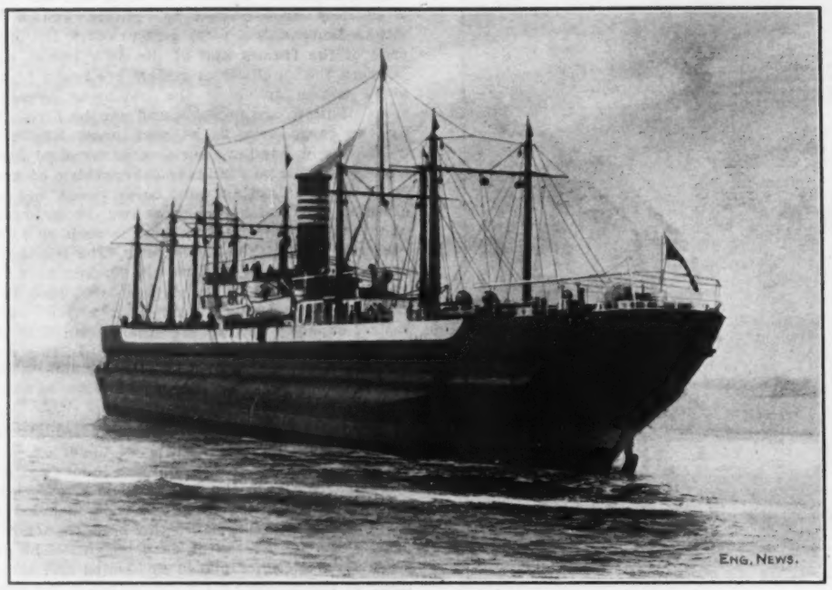

FIG. 5. TURRET-DECK TRAMP STEAMER "POPLAR BRANCH."
Wm. Doxford & Sons, Sunderland, England, Builders.

The question of the allowable working stress for steel in the reinforcement of concrete for irrigation structures hinges on the liability of the percolation of water into the concrete, thus producing corrosion and rusting of the metal. The degree of danger from this cause depends upon the amount of such percolation and consequently is greatly enhanced by tension cracks in beams and slabs. Experiments show that microscopic cracks begin to exist on the tensile side of beams when the stress in the reinforcing steel reaches from 3,000 to 5,000 lbs. per sq. in., and that these cracks become visible to the naked eye at unit stresses from about 12,000 to 16,000 lbs. per sq. in. The widths of such cracks for stresses above 5,000 are directly proportional to the stress in the steel. If E represents the modulus of elasticity of steel, S the unit stress, and y the unit elongation due to that stress, then $y = S$ divided by E. E may be taken at 30,000,000 for all grades of steel, as the modulus of the elasticity of steel is practicaly a constant. Whence $y = S$ divided by 30,000,000 and the elongation is seen to be directly proportional to the unit stress. If the cracks in a beam are assumed to have the same distribution irrespective of the stress in the steel and if the danger from percolation is assumed to be proportional to the width of the cracks, it is apparent that double the amount of damage may result to the steel from this source by doubling its working stress. Just how much damage such cracks may cause is a question, but that their presence is an element of possible, if not absolute, danger is beyond doubt. Conservative designing must recognize this element of danger and eliminate it within the limits of reasonable economy.

The dictation of extreme precaution would require the adoption of a working stress for steel of about 5,000 lbs. per sq. in., while that of extreme economy might in many instances call for some such working stress as 25,000 lbs. per sq. in. Evidently the solution of the problem, therefore, requires the fixing of a maximum unit working stress that may be used except where the economical percentage of reinforcement permits the use of a lower stress. The writer would suggest 15,000 lbs. per sq. in. for this maximum unit working stress for ordinary conditions, which has the merit of being the mean of the extreme requirements above referred to and permits of the use of commercial grades of medium steel. Where the safety of a structure depends on the resistance of a few reinforcing bars, as in girders, the working stress should not exceed 12,000 lbs. per sq. in.

The danger of percolating water through tension cracks is also a controlling element in the selection of the size of reinforcing bars for concrete in irrigation structures. The strength of a steel reinforcing bar is directly proportional to its cross-sectional area, while the corrosive action of water on it is directly proportional to its cross-sectional perimeter. Whence the ratio of the corrosive action of water on a bar to the strength of the bar varies inversely as its diameter. Evidently, therefore, the larger the diameter of a steel reinforcing bar the less of its proportional strength will be impaired by corrosion in a given time, and the largest sized bars consistent with other conditions should always be chosen.

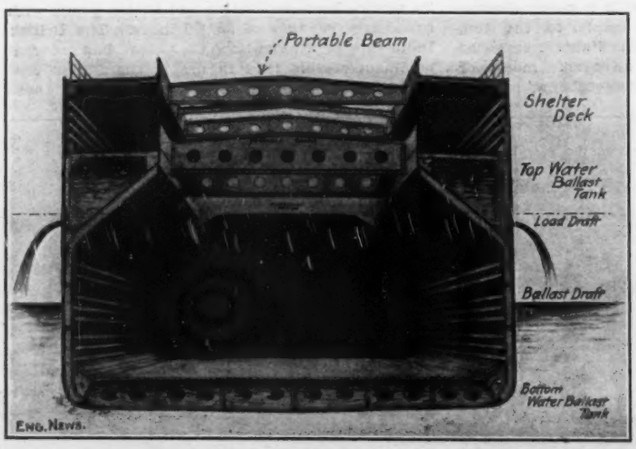

FIG. 6. HULL CONSTRUCTION WITH CANTILEVER FRAMES AND TOP-SIDE WATER BALLAST TANKS (HARROWAY & DIXON SYSTEM).
Sir Rayiton Dixon & Co., Middlesbrough, England,

Intimately connected with the question of the size of bars is the subject of spacing them. Normally the writer prefers spacings varying from 9 to 12 ins. c. to c., with an occasional rise to 15 ins. and an occasional drop to 6 ins. As a general rule it may be stated that the spacing should seldom exceed the effective depth of the beam, and should always be less than 1.5 times that depth. Such spacing will ordinarily be sufficiently close to transmit the adjacent strains properly and to permit of easy and proper deposition of the concrete.

In architectural practice it is customary to use a protective depth of concrete below the steel which for irrigation structures would be inadequate. It seems certain that such thicknesses of concrete outside of the steel as ½ to 1 in. should never be used in outdoor structures especially subjected to the action of weather and water regardless of the thickness of the concrete or the cross-section of the steel. The application of reinforced concrete to irrigation structures is comparatively new, and no well-established rule has been developed for this class of work. Imperfect work next to the forms may leave the steel exposed. Through only ordinarily careless work a deviation of ½-in. either in the plane surface of the forms or in the position of the steel reinforcement is very likely. These deviations working conjointly may bring the steel entirely to the surface of the concrete. The formation of poor concrete adjacent to the forms, especially in dry concrete, is exceptionally likely to occur owing to insufficient moisture in the forms; also pockets of poorly mixed concrete may accidentally come near the surface of the concrete. All of these conditions are likely to cause undue exposure of the steel and consequently the ultimate collapse of the structure. In view of these facts the writer believes that for concrete of 1:2:5 mixtures and richer it is good practice to require a minimum protection for steel of at least 2 ins. This minimum value should be increased for leaner mixtures of concrete and for beams with greater effective depths than 12 ins.

Owing to the isolation of small irrigation structures it is difficult to provide for adequate equipment for accurately bending reinforcing steel for concrete. All necessary bending should, therefore, be as simple in character and as easy of execution as possible. The designer should make every required bend meet an economical structural need. However, the cost of executing a complicatedly bent system of reinforcing steel for concrete is less objectionable than the likely displacement of the bars from their assumed location due to inaccurate measurements of distances between bends and of the angles thereof. A small displacement of the steel may bring it too close to the surface of the concrete or in a shallow beam may cause considerable decrease from the computed strength of the beam. It is true that the designer should take all such contingencies into account in determining the depth of beam to withstand a given load, but it is also true that the more of such uncertainties he eliminates the more economically he can design. Economic and rational designing calls for a certain amount of bending of reinforcing bars to provide for shear, continuity, stresses and bonding anchorage; but care should be exercised not to provide for these stresses where their intensity does not require it and to provide for them by other equally economical means when possible.

Generally speaking, the matter of proper bond-

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$$M_4 = \frac{4P\left(\frac{L_4}{2} - \frac{15}{4}\right)^2}{L_4} - 5P \qquad (4)$$

By equating equations (1) and (2) and calling $L_2 = L_3 = L$ we can find the length of span below which one load only will produce the maximum moment and above which two loads 5 ft. apart will give greater moments than the single load, thus

$$\frac{PL}{4} = \frac{2P\left(\frac{L}{2} - \frac{5}{4}\right)^2}{L}$$

from which $L = 8.5$ ft.

Similarly by equating equations (2) and (3) we find the length of span below which two wheels give greater moments than three wheels,

$$\frac{2P\left(\frac{L'}{2} - \frac{5}{4}\right)^2}{L'} = \frac{3P\left(\frac{L'}{2} - \frac{5}{3}\right)^2}{L'} - 5P$$

from which $L' = 29.3$ ft.

In a similar manner by equating equations (3) and (4) we find that L'' equals 34.4 ft., that is, for spans less then 34.4 ft., three wheels give greater moment than four wheels, while for spans over 34.4 ft. four wheels give the greater moment.

It is customary to add to the above absolute maximum live-load moment the dead-load moment at the center of the span. Except in cases where the absolute maximum moment occurs at the center of the span, this is slightly incorrect, but is on the safe side.

The determination of the maximum end shears is very simple. It is evident that for spans of 5 ft. and under the maximum end shear will occur with one wheel on the span, for spans between 5 and 20 ft. with two wheels, between 20 and 25 ft. three wheels, and above 25 ft. four wheels on the span. In each case the leading wheel is placed just at the support.

The accompanying table of moments and shears has been worked out for a 100,000-lb. car with a wheel spacing of 5—15—5 ft., and has been carried to those lengths of spans where a uniformly distributed load of 1,800 lbs. per foot of track causes maximum moments and end shears equal to those caused by one car.

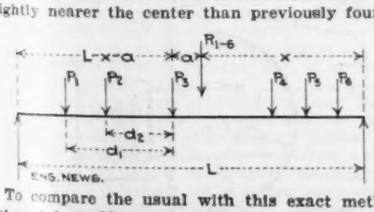
It is interesting to notice that if the dead load be taken into account, the common derivation for the moment at load P_3 is incomplete. The expression for the moment may be written as follows, with reference to the sketch below:

$$M = \frac{R\,x}{L}(L - x - a) - \Sigma Pd + w(L - x - a)\frac{(x + a)}{2}$$

where w is the uniform load per unit of length. The value of x which will make this a maximum is obtained by differentiating M with respect to x, and placing the result equal to zero. This process gives

$$x = \frac{L}{2} - a\left(\frac{wL + R}{wL + 2R}\right)$$

Since in this value of x the part within the parenthesis is greater than ½, the value of x is less than for the case where only the live load was considered; which means that for the exact absolute maximum moment the load P_3 should be slightly nearer the center than previously found.



To compare the usual with this exact method let us take a 60-ft. span with 100,000-lb. car and a total dead weight of 800 lbs. per ft. The absolute maximum moment for the live-load alone is

$$= \frac{50000(30 - 15/4)^2}{60} - 62500 = 511719 \text{ ft. lbs. per rail.}$$

The dead-load moment at the center is 180,000 ft.-lbs. per rail. The customary approximate method of adding the absolute maximum live to the maximum dead moment would therefore give in this case a total amount of 691,719 ft.-lbs.; whereas the correct method would give a combined maximum moment of 689,451 ft.-lbs. All of which goes to show that the customary approximate method is sufficiently accurate.

The analysis and computations in this article deal only with bridges in which the load comes directly on the main trusses or girders, as deck or pony through plate-girder bridges. When the floor-system comprises stringers and floorbeams, the maximum moment must of course occur at one of the floorbeams.

TRANSVERSE CONTOURS FOR ROADWAY PAVEMENTS.

The determination of the crown and transverse contours for roadways has been the subject of articles in Engineering News for Nov. 20, 1902, and Jan. 31, 1907. The following tables on the same subject are taken from a paper read by Mr. H. H. Gladding, M. Am. Soc. C. E., Assistant City Engineer of New Haven, Conn., before the 23d annual meeting of the Connecticut Society of Engineers, at Hartford, Conn., Feb. 12-13, 1907.

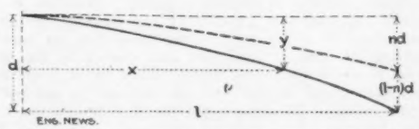
TRANSVERSE CONTOURS FOR ROADWAY PAVEMENTS.

$x =$	⅛l	¼l	⅜l	½l	⅝l
n = ½	.132	.278	.438	.611	.799
⅓	.120	.259	.417	.593	.787
½	.097	.222	.375	.555	.764
⅔	.074	.185	.333	.518	.741
¾	.062	.167	.313	.500	.728

$x =$	⅛l	¼l	⅜l	½l	⅝l	¾l	⅞l
n = ¼	.078	.203	.316	.438	.566	.703	.848
⅓	.089	.188	.297	.417	.547	.697	.838
½	.070	.156	.258	.375	.508	.656	.820
⅔	.052	.125	.219	.333	.468	.615	.802
¾	.043	.109	.199	.313	.449	.609	.792

$x =$	.1l	.2l	.3l	.4l	.5l	.6l	.7l	.8l	.9l
n = ¼	.078	.160	.248	.340	.438	.540	.648	.760	.878
⅓	.070	.147	.230	.320	.417	.520	.630	.747	.870
½	.055	.120	.195	.280	.375	.480	.595	.720	.855
⅔	.040	.093	.160	.240	.333	.440	.560	.693	.840
¾	.033	.080	.143	.220	.313	.420	.543	.680	.833

$x =$	.1l	.2l	.3l	.4l	.5l	.6l	.7l	.8l	.9l
n = .1	.091	.184	.279	.376	.475	.576	.679	.784	.891
.2	.082	.168	.258	.352	.450	.551	.658	.768	.882
.3	.073	.152	.237	.328	.425	.528	.637	.752	.873
.4	.064	.136	.216	.304	.400	.504	.616	.736	.864
.5	.055	.120	.195	.280	.375	.480	.595	.720	.855
.6	.046	.104	.174	.256	.350	.456	.574	.704	.846
.7	.037	.089	.153	.232	.325	.431	.553	.688	.837
.8	.028	.072	.131	.208	.300	.408	.532	.672	.928
.9	.019	.056	.111	.184	.278	.384	.511	.656	.819



Let l represent the horizontal distance from the vertex to the lower end of the curve.

Let d represent the total difference in elevation between the ends of the desired curve.

Let nd be any assumed portion of d.

Let (1 — n) d be the remaining portion of d.

Let x and y be the coordinates of any point on the curve, the origin being at the vertex.

The broken line in the sketch is a preliminary curve tangent to the horizontal at the vertex, and with its lower end at a distance nd below said horizontal line; its ordinates will be found by the usual parabolic formula, $y = \frac{x^2}{l^2}\,nd$.

Suppose this curve to be rotated about the vertex until its lower end has moved downward through the remaining portion of d, viz., (1 — n)d: the additional ordinates caused by this rotation will be in direct proportion to their horizontal distances from the vertex, and will be expressed by $\frac{x}{l}(1 - n)d$.

The sum of these two partial ordinates will, of course, give the ordinates of the curve in its final position; so that we have for the general equation, $y = \frac{x^2}{l^2}\,nd + \frac{x}{l}(1 - n)d$, from which equation the tables were computed.

The advantages of this tipped down curve are an increase of initial pitch at the vertex, and a lessening of the slope at the steepest part of the curve.

The amount of the total ordinate d of the curve is a matter for the judgment of the engineer in charge. d = .04 l will probably be sufficient for roads carefully shaped by a road roller. For very smooth, hand-laid pavements, d = .03 l would seem ample.

Example:—l = 15 ft. d = .04 l, = 0.6 ft.; take n = ⅔. From the table, the ordinates at ⅛, ½ and ⅞ of the distance from the vertex to the gutter will be .11d, .31d and .61d; or in feet, 0.066 ft., 0.186 ft., 0.366 ft.

The initial pitch at the vertex is the amount of the tip down, (1 — n)d, divided by l, and in the above example amounts to .01, a one per cent. grade.

The middle ordinate between the curve and its subtending chord is equal to ½d minus the middle ordinate to the curve from the horizontal line through the vertex as taken from the table in terms of d; and in the example used is .5d — .31d = .19 × .6 ft. = .114 ft.

BOILER SCALE IN RELATION TO HEAT TRANSMISSION IN BOILER TUBES.

One of the serious troubles resulting from the use of bad water in locomotive boilers is the effect of the scale on the tubes in reducing the heat transmission and the consequent reduction in the efficiency of the boiler. This has been the subject of numerous investigations, the latest of which have been made at the Engineering Experiment Station of the University of Illinois. The results of these studies were presented at the March meeting of the Western Railway Club, Chicago, by Mr. E. C. Schmidt, Associate Professor of Railway Engineering at the university. After reviewing some of the earlier investigations he dealt with the experiments above referred to, which were made for the purpose of determining the difference between the conductivity of each scaled tube and that of a clean tube of the same diameter, thickness and length. The following is an abstract of the particulars of the tests:

The tubes were removed from locomotives which had been in operation in various parts of the south and middle west. For each tube the thickness of scale was determined by calipering every 6 ins. of its length. The scale was examined and characterized as either hard, soft, or medium; and for each tube a chemical analysis was made of the scale.

The apparatus in which the tubes were tested consisted essentially of a long water chamber, through which the tube to be tested was passed, and through which water was circulated. At one end of this water chamber was fastened a combustion chamber with which the tube communicated, and the heat delivered to the tube was supplied by the combustion of gas in this chamber. The heat abstracted from the tube was determined by weighing the water which passed around the tube and through the water chamber, and by noting its rise in temperature. For each series of tests the gas and air needed for combustion were delivered to the burner at constant pressure for all tests, and in approximately the same amounts.

After adjusting the supply of water to the water chamber, the burner was lighted and the flow of gas and air regulated to the desired amounts. The apparatus was then allowed to run until all conditions had become stable. This usually required about one hour, at the end of which period the test was started. Observations were taken, at 5 or 10 minute intervals, of the temperature of the gases at entrance to the tube and at exit, as well as of the water temperature at entrance and exit of the water chamber. The amount of water used was determined by weighing. The purpose of the tests was to determine the number of thermal units transmitted per hour through each tube. This equals the weight of water circulated multiplied by its rise in temperature.

When the experiments were planned it was considered probable that the transmission of heat through the scale was principally dependent upon two of its characteristics; namely, its thickness and its mechanical structure, and that probably, for such thicknesses as are usually met with, thickness had greater influence than structure. Thickness was therefore carefully determined and structure approximately designated as hard, soft or medium, no more exact characterization of structure being possible with tubes collected from different sources.

It was hoped that the experiments might develop, if perhaps only approximately, some law of variation of conductivity with thickness. After making allowance for possible errors due to the method of conducting the tests, the result shows perhaps a decrease of conductivity

RAILWAYS.

The railway system of India at the beginning of 1907 may be said to consist of 29,000 miles of lines in operation and 3,000 miles under construction or approved for construction.

In the 50 years since the Sepoy mutiny the governing motive in the building of railroads has been military necessity, or supposed necessity, with trade and industry as minor considerations.

Several years ago a report made by a commission fixed 60,000 miles as the amount of mileage desirable in order to give India a railway system which would answer all her needs. The approach to the 60,000 miles is so gradual that its ultimate realization is very far off—much farther than if the field were open to private enterprise—yet the policy which now obtains insures continuous building and a certain regularity of construction along given routes.

In addition to its subordination to military requirements the railway system is completely under state authority. State socialism, which enters so largely into all branches of English administration in India, blooms and flowers in the rigid paternal control of the means of communication. The government actually owns the larger part of the mileage, and operates its own railroads to their minutest details. In other cases where existing lines were bought by the government they were leased to private companies, which operate them nominally as such, but actually as agents of the state. About the only opening for private enterprise is in the construction of branch lines forming feeders either to lines worked by the government or to leased railways worked by the companies.

The railroads are under the direct supervision of the railway board, which consists of three members. The duties of this board are very comprehensive. It prepares what is called a program of general railway policy, though the broader question of policies and finance are dependent on the ultimate decision of the viceroy and council. The administrative work of the board includes the construction of new lines, the traffic arrangements, the regulations of rates, and the minute supervision of operation whether of the state lines or of those operated by private companies. The board seeks to secure continuous railway development by means of a triennial program; that is, it lays out the construction and repairs and maintenance which are considered desirable for a period of three years. For the present triennial period its plans contemplate the expenditure of about $50,000,000 annually, which expenditure is 20% greater than for the previous years.

The railway board, or rather the government, is under a steady fire of criticism on account of the shortage of cars during the busy season. The official justification for this shortage usually put forth is that it also happens in the United States. The difference, however, is that in the United States there is competition, and when existing lines continuously fail to meet the requirements of transportation new railroads are built, or else competing roads manage to secure equipment and obtain the freight. In India no such relief is possible.

MAXIMUM LIVE-LOAD BENDING MOMENTS AND SHEARS FOR BRIDGES CARRYING ELECTRIC CARS.

By FRANK P. McKIBBEN,* M. Am. Soc. C. E.

In designing bridges to carry electric railways one should bear in mind that besides the ordinary passenger cars there are other types which frequently should be considered, namely, construction, service and freight cars. The development of freight traffic upon electric roads makes the consideration of the freight car an important element in choosing loads to be used in designing. However, as the weight and wheel-spacing of service and construction cars will vary widely from case to case, passenger cars only will here be considered.

In the last 8 or 10 years the increase in weight of single-truck cars has been so small and that of double-truck cars so large that, in designing, the latter type only need be used. Except in some special cases of unusually heavy urban or interurban railways it seems reasonable to assume for a passenger car a double-truck car weighing, together with its maximum load, 100,000 lbs. This should be sufficient to provide for a considerable future increase in weight of cars, but, judging from past experiences with such increases of locomotives on steam railroads, it is difficult to predict with any certainty regarding future loadings for electric cars. In the special cases to which reference is above made where unusually heavy cars are now in use a loading of 120,000 lbs. should be used. It should be remembered that the weight of a car is sometimes unequally distributed over its wheels.

The average unloaded weight of the heaviest double-truck passenger cars now being operated upon 57 electric railways of Massachusetts is 40,000 lbs. The smallest weight used in finding this average is 20,000 lbs. and the largest 72,800 lbs. These figures give the weight of the car alone. Assuming 150 passengers at 120 lbs. each, the loaded weight of the average car becomes 58,000 lbs. and the maximum 90,800 lbs. The average wheel base of a truck for these cars is 5 ft., and the average distance center to center of trucks is 20 ft. This makes the spacing between rear wheel of front truck and front wheel of rear truck 15 ft. The wheel spacing between cars, when two or more cars are run coupled, will not be far from the same amount, so that the concentration of a single car is to be regarded as a maximum for all spans less than 45 ft. long.

The criterion for finding the position of a system of concentrated wheel-loads to produce the greatest possible bending moment upon a given span is well known, and may be stated as follows:

When the center of span is halfway between the center of gravity of loads on the span and the wheel nearest this center of gravity, then the bending moment under this wheel is a maximum, and this is the greatest moment which the given combination of loads can produce in the span.

In applying this principle, it will generally happen that not all the wheels of a series can be placed on the span at one time, at least not in such position as to satisfy the condition as to center of gravity. It then becomes necessary to try several positions of the series of loads. The method of procedure is, then: Assume some of the loads on the span so as to bring the heavy loads as near the center of the span as possible and so as to have as many loads on as possible. Find the position of the resultant of these loads and place the center of the span midway between the resultant and the nearest load. If all the loads assumed on are now really on the span compute the moment at the nearest load just mentioned. If when the above assumed loads are placed in the position just cited some of the loads assumed on the span are really off the span, it is then necessary to try again, using a new resultant. Unless one can tell by inspection it would be necessary to compute in this manner the maximum moment at several of the loads until the greatest possible moment is found. This latter is called the absolute maximum moment. It is evident that when the resultant coincides with one of the loads the greatest possible moment that can occur at this wheel is when it and the resultant lie at the center of the span.

Passing now to the study of the absolute maximum moments under a double-truck electric car with four equal axle loads with a wheel spacing of 5—15—5 ft., as shown at the head of the subjoined table, we see that there are four cases, namely, where the maximum moment is caused respectively by one, two, three, or four loads on the span. Obviously for certain short spans one load only on the span will cause the maximum, for somewhat longer spans two loads, etc. The limiting lengths separating these groups can be computed.

Case 1. One load only on the span.—The maximum moment will occur at the center when the load is at the center. It is equal to

$$M_1 = \frac{P L_1}{4} \qquad (1)$$

where P is one wheel load and L_1 is the length of span.

Case 2. Two loads on the span.—Place the wheels so that the center of the span comes midway between the resultant of the two loads and one of the loads, and the maximum moment will occur at the load which is 1¼ ft. from the center; and is equal to

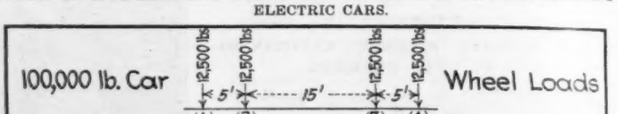
$$M_2 = \frac{2\,P\left(\frac{L_2}{2} - \frac{5}{4}\right)^2}{L_2} \qquad (2)$$

Case 3. Three loads on the span.—The resultant of three loads will lie 3⅓ ft. from load No. 2. Hence the maximum moment will occur at wheel No. 2 when the center of the span lies 1⅔ ft. from the load and is equal to

$$M_3 = \frac{3\,P\left(\frac{L_3}{2} - \frac{5}{3}\right)^2}{L_3} - 5\,P \qquad (3)$$

Case 4. Four loads on the span.—The maximum moment will occur at load 2 when this load is 3¾ ft. from the center and is equal to

TABLE OF LIVE-LOAD END SHEARS AND MOMENTS IN BRIDGES CARRYING ELECTRIC CARS.



Maximum End Shears						Maximum Moments					
Span in Feet	Wheels for Max.	Max. End Shear (lbs. per Rail)	Span in Feet	Wheels for Max.	Max. End Shear (lbs. per Rail)	Span in Feet	Wheels for Max.	Max. Moment (ft.lbs. per Rail)	Span in Feet	Wheels for Max.	Max. Moment (ft.lbs. per Rail)
5	1	12500	51	1	37700	5	1	15600	51	1	401300
6	1	14600	52	1	38000	6	1	18800	52	1	413500
7	1	16100	53	1	38200	7	1	21800	53	1	425800
8	1	17200	54	1	38400	8	1	25000	54	1	438000
9	1	18100	55	1	38600	9	1	29300	55	1	450300
10	1	18750	56	1	38800	10	1	35200	56	1	462600
11	1	19300	57	1	39000	11	1	41100	57	1	474800
12	1	19800	58	1	39200	12	1	47000	58	1	487100
13	1	20200	59	1	39400	13	1	53000	59	1	499400
14	1	20500	60	1	39600	14	1	59000	60	1	511700
15	1	20800	61	1	39800	15	1	65100	61	1	524000
16	1	21100	62	1	39900	16	1	71200	62	1	536300
17	1	21300	63	1	40100	17	1	77900	63	1	548700
18	1	21600	64	1	40200	18	1	83400	64	1	561000
19	1	21700	65	1	40400	19	1	89600	65	1	573300
20	1	21900	66	1	40500	20	1	95700	66	1	585700
21	1	22600	67	1	40700	21	1	101900	67	1	598000
22	1	23900	68	1	40800	22	1	108000	68	1	610300
23	1	23900	69	1	40900	23	1	114200	69	1	622700
24	1	24500	70	1	41100	24	1	120400	70	1	635000
25	1	25000	71	1	41200	25	1	126600	71	1	647400
26	1	26000	72	1	41300	26	1	132800	72	1	659800
27	1	26900	73	1	41400	27	1	138900	73	1	672100
28	1	27700	74	1	41600	28	1	145100	74	1	684500
29	1	28400	75	1	41700	29	1	151300	75	1	696900
30	1	29200	76	1	41800	30	1	159700	76	1	709300
31	1	29800	77	1	41900	31	1	169000	77	1	721600
32	1	30500	78	1	42000	32	1	178300	78	1	734000
33	1	31100	79	1	42100	33	1	187500	79	1	746400
34	1	31600	80	1	42200	34	1	196800	80	1	758800
35	1	32100	81	1	42300	35	1	207600	81	1	771200
36	1	32600	82	1	42400	36	1	219500	82	1	783600
37	1	33100	83	1	42500	37	1	231500	83	1	796000
38	1	33600	84	1	42600	38	1	243500	84	1	808400
39	1	34000	85	1	42600	39	1	255500	85	1	820800
40	1	34400	86	1	42700	40	1	267600	86	1	833200
41	1	34800	87	1	42800	41	1	279600			
42	1	35100	88	1	42900	42	1	291700			
43	1	35500	89	1	43000	43	1	303800			
44	1	35800	90	1	43100	44	1	316000			
45	1	36100	91	1	43100	45	1	328100			
46	1	36400	92	1	43200	46	1	340300			
47	1	36700	93	1	43300	47	1	352500			
48	1	37000	94	1	43400	48	1	364600			
49	1	37200	95	1	43400	49	1	376900			
50	1	37500	96	1	43500	50	1	389100			

*Associate Professor of Civil Engineering, Massachusetts Institute of Technology, Boston, Mass.

use a hacksaw at 25 cts. per hour, the saw would be the cheaper. The current used was at 50 volts, which was stated to be more satisfactory than either 25 or 105 volts. Tests showed 650 amperes consumed at the arc, which at 50 volts equals about 32 KW.

BOULDERS.—In passing a line of steel sheeting around a boulder of large size, special angle or bent piling sections are desirable to make the departure from and return to the line as planned. Some of the types of

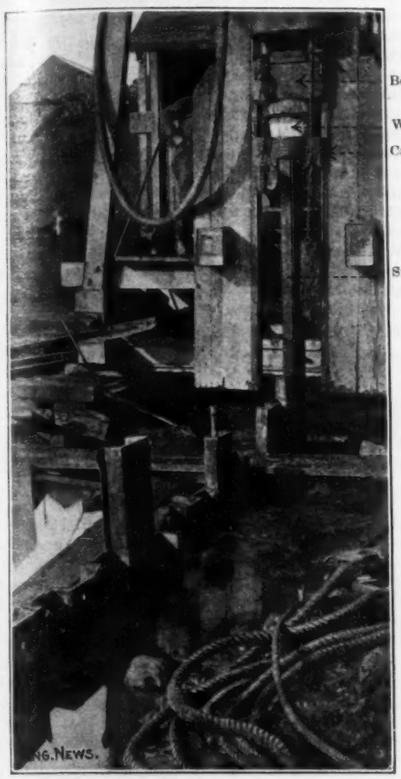


Fig. 3. Driving Steel Sheet Piling.

sheeting, like the Quimby or the United States, adapt themselves readily to such changes of alinement without using special pieces. Bending a ⅜-in. or ½-in. web longitudinally to short radius in the field is not an easy matter. When using rigid non-reversible interlocked piling in quicksand, and on work of such character that close water-tightness is required, special corner pieces should be kept on hand for emergencies. In some soils it may be permissible at times to turn corners by driving outside the interlock and tight against a projecting flange, placing the new piling at any angle required. Sometimes it may be feasible to fill gaps and make closures with specially prepared squared wood piles, with points beveled to make the wood piling hug the steel.

In hard driving among stones, only a type of piling of great stiffness laterally and with perfect interlocking features will insure success. On such work there must be no alternate unstiffened sections of piling. The interlock must be perfect and confining, difficult to open up and permit the escape of the inside member. Even with the heaviest and most confining type of interlocked piling now on the market in this country, this opening of interlock will sometimes occur when boulders are encountered. Small boulders in gravelly soils are usually displaced without trouble. Sometimes the aid of a water jet is a help. Usually steel piling will drive easily enough in ordinary soils without a jet. In hard clays a jet is not of much assistance and is very slow. Obviously it is not often required to drive steel sheeting far into hard clays.

In driving four lines of steel piling across the valley of the Muskegon River in Mecosta and Newaygo counties, Michigan, the borings showed "floating" masses of clay hardpan sometimes several hundred feet across, and from one foot to 12 ft. thick. Below was quicksand before reaching a bed of hardpan continuous across the valley at a depth of about 30 ft. Hence the necessity for driving through the floating hardpan. (See Fig. 4.) The hardpan in question consisted of about 70% of bluish clay and 30% of sharp sand, well mixed and compacted by water deposition and pressure, to the texture of frozen soil. In this hardpan were stones from gravel up to boulders of 5 tons weight. This material cost $3 per cu. yd. to trench, and angular fragments would lie for months in water moving with a velocity of 5 ft. per second without material erosion or change in form. This was at the Big Rapids dam* of the Grand Rapids & Muskegon Power Co., in 1905. Lubricating the piling with grease before driving, and with a stream of water under pressure when driving, seemed to be of no special aid in the hardpan mentioned.

On the work at the Big Rapids Dam, above mentioned, the single-channel Friestedt piling frequently buckled and recourse was then had to double Z-bar sections entirely. This piling with two Z-bars on all pieces weighs about 54 lbs. per sq. ft., and to reduce the weight the writer has had a single Z-bar riveted to every channel instead of using double Z-bar channels exclusively or alternating with plain channels. The single Z-bar to every channel permits always having the free or uninterlocked edge of the pile being driven stiffened by a Z-bar. On this type, shown at No. 3 in Fig. 1, the writer has obtained a patent and has used over 1,000 tons with satisfactory results. Nearly all of this was driven into hard soils. On the Muskegon River work one car-load was used of a special rolled type of piling having less radius of gyration than the built-up types above mentioned. Of this piling fully one-half buckled; it was thrown away and replaced with the other type.

PULLING PILING.—The manufacturers of steel piling place much stress on the ability to pull up the piles, but in his experience in hard soils the writer has never been able to get jacks enough on a piece of steel piling driven 12 ft. in the ground to pull it out. In soft river mud and silt, pulling with heavy tackle can be done. Probably a hammer striking upward blows in the manner similar to that used in pulling pipe casings from test bore holes would be operative except in cases of badly crimped and bent piles.

COST OF PILING.—In lots of 500 tons, Friestedt steel piling sold in 1904 and 1905 at $1.93 per 100 lbs. on cars at the mill. This on alternate double Z-bar and channel and plain channel type. In May, 1906, this type sold at $2.03, and $2.23 with a Z-bar on every channel, the additional price being on account of extra handling when every piece has to be riveted. The plain channels require only a 1-in. hole punched in the end for lifting.

The cost of driving per lin. ft. of piling 13¾ ins. net width, with a steam hammer, on the Muskegon River work above mentioned ran from 7¼ cts. to 20 cts. per sq. ft. in place. Labor at 20 cts. per hour; foreman, 25 cts. The 7¼ cts. cost was on land in sand and gravel with some clay strata; piling 20 to 40 ft. long. The average amount of piling driven per hour in fairly good ground is 40 to 50 lin. ft., or 400 to 500 lin. ft. per day of 10 hours, including the time of moving the pile driver. In general the cost per sq. ft. for driving steel sheeting is 25% less than for driving wood.

SPLICING PILING.—The longest single lengths driven on the writer's work was 44 ft., but spliced lengths up to 58 ft. have been successfully used. In doing spliced work it is not necessary to actually bolt or rivet the splices, the procedure being to use two lengths so as to break joints in the interlock. For 58-ft. piling, suppose we use 36-ft. and 22-ft. lengths: First drive the 36-ft. piece down, then move back and drive a 24-ft. pile down within a foot of the top of the 36-ft. piece; now move forward and set a second 22-ft. piece on top of the first 36-ft. piece and drive both down to full depth. Now move back past the 24-ft. pile and drive a 36-ft. piece in No. 3 position; then a 32-ft. piece on top of the 24-ft. piece. By moving back and forth so as not to lose the interlock below ground only two different lengths are required.

*Engineering News, May 31, 1906.

TOTAL STREAM DISCHARGE DIAGRAM.

By HAROLD PETTERSON.*

While engaged in engineering work for the Los Angeles Aqueduct, I used a method for determining the total discharge of a stream for a given period of time, which to me seems very simple and adaptable to many hydraulic problems.

In spite of the admirable work now being done by the hydrographic branch of the U. S. Geological Survey, the hydraulic engineers in the western states frequently have but a limited number of stream measurements from which to determine the discharge of a stream and the mean daily flow. Thus, for the discharge curve shown in the diagram, the total stream measurements available during the years 1904 and 1905 are as tabulated herewith. Gage readings had been taken between successive stream measurements, but not of sufficient number to warrant preparing a rating table.

STREAM DISCHARGE ON VARIOUS DATES.

1904			1905	
Date	Discharge.		Date	Discharge.
Jan. 11	50	sec. ft.	Jan. 6	55 sec. ft.
Jan. 21	55	"	Feb. 5	70 "
Feb. 10	80	"	Mar. 5	60 "
Mar. 2	65	"	Mar. 27	50 "
Mar. 12	55	"	Apr. 23	52 "
Apr. 1	56	"	May 11	95 "
Apr. 21	50	"	June 5	135 "
May 21	48.5	"	July 5	150 "
June 10	70	"	July 25	135 "
June 30	100	"	Sept 13	100 "
July 30	120	"	Oct. 23	55 "
Aug. 15	130	"	Dec. 31	60 "
Sept. 8	90	"		
Oct. 28	47	"		
Nov. 27	50	"		

In the diagram, the days of the month are platted as abscissas and the measured discharge as ordinates, as in the regulation discharge diagrams. The area between the curve so obtained and the base line represents the total flow for the period of time considered. Thus, a uniform flow of 1 sec.-ft. for 24 hrs. is equivalent to 1.98 acre-feet. This is represented graphically by a rectangle whose height indicates 1 sec.-ft. and whose width indicates 1 day. In the diagram shown, the horizontal scale is 1 in. = 40 days, and the vertical scale 1 in. = 20 sec.-ft. Thence 1 sq. in. = 20 × 40 × 1.98, or 1,584 acre-feet. The planimeter can be set to read acre-feet directly. A convenient reading for the scale, as here used, is 1 division on the vernier for each 20 acre-feet.

The total discharge for any given period can be very quickly found. The accuracy of the result can be made to correspond with the accuracy and number of the actual stream measurements by varying the scale of the diagram. The mean daily flow is obtained from the total discharge by dividing by 1.98 times the number of days. Having determined upon and drawn the line of daily draft, the required capacity of storage reservoirs can be found for monthly and yearly regulation of supply. Such a diagram can be understood by "laymen," while even some hydraulic engineers do not understand the Freeman mass curve.

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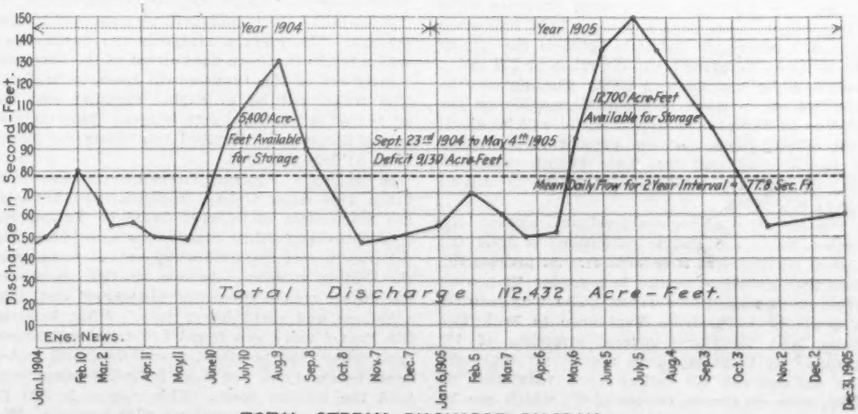

TOTAL STREAM DISCHARGE DIAGRAM.

(For simplicity, only every tenth day is indicated, and the name of each successive month is given but once.)

with thickness; but certainly no regularity of variation. No regularity of variation is observable with respect to hardness or softness.

It must be borne in mind that the tubes tested were taken from locomotives which had been in service in different parts of the country and that the scale on each tube was made up of the mineral constituents of many different water supplies. What was designated as hard scale in one case may be very different in structure (in porosity, for example) from that designated as hard scale on another tube. The results cannot therefore be considered as providing conclusive evidence concerning variation of conductivity with structure. They may properly be interpreted as indicating that mechanical structure is at least as important a factor in the change in heat transmission due to scale as is the mere thickness. Such a conclusion is, of course, in accord with the facts concerning other heat insulators.

It seems probable that soft, porous scale would more effectively retain against the tube surface a layer of water or vapor of low conducting power, and we should accept with caution the assumption that hard scale will cause a greater loss than soft scale. The diagrams in which the loss in heat transmission is plotted with reference to the principal chemical constituents of the scale, do not warrant the conclusion that its chemical composition has any direct influence on its conductivity.

Conclusion.—In so far as generalization is warranted we may sum up the results of the tests in the following conclusions:

1. Considering scale of ordinary thickness (say varying up to ⅛-in.) the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12%.

2. The loss increases somewhat with the thickness of the scale.

3. The mechanical structure of the scale is of as much or more importance than the thickness in producing this loss.

4. Chemical composition, except in so far as it affects the structure of the scale, has no direct influence on its heat transmitting qualities.

EXPERIENCE WITH STEEL SHEET PILING IN HARD SOILS.*

By WM. G. FARGO.†

Steel sheet piling is used for purposes entirely similar to wood sheet piling, but is much more certain in results obtained. The principal applications of steel sheet piling are as follows: (1) Cofferdams: For building and structure foundations, including bridge piers and abutments. Also for mine shafts where the piling may be forced down in the manner of a caisson or shield. (2) Dams: For the dam itself, as for low dams; thus requiring no other cofferdam or pumping out of the foundation pit. As a cut-off across a valley under a dam or beneath a core wall. As a permanent enclosing wall down to an impervious stratum for the masonry structure of the dam, or for power-house or other building not necessarily part of a dam; or as a downstream toe protection only. (3) Retaining Wall: Temporary or permanent as required in building footings close to an existing structure. This use is essentially similar to the cofferdam.

*A paper read at the annual meeting of the Michigan Engineering Society, and published in the Proceedings of the Society for 1907.

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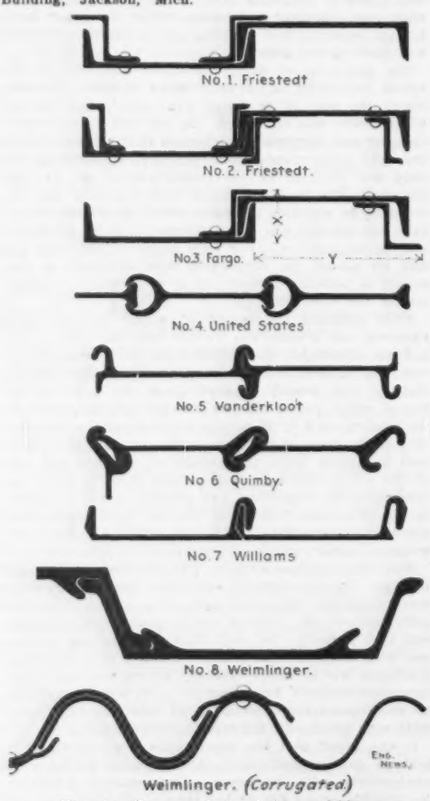


Fig. 1. Forms of Steel Sheet Piling.

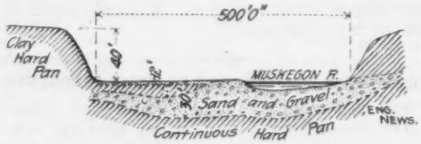


Fig. 4. Cross-Section at Site of Big Rapids Dam in the Muskegon River, Michigan.

The types or varieties of steel sheet piling are as follows: (A) Special rolled sections, composed of forms requiring special rolls for producing the piling. If there are return bends, or flanges transverse to the plane of rolling, the piling must pass through a series of special rolls. (B) Built-up sections. Usually built up from standard structural steel shapes. These may consist of single webs with riveted interlocking members, or of double parallel webs held in relative position by bolts and pipe separators. The double-web sections are usually driven alternately with single web members. A number of forms of steel sheet piling are shown in Fig. 1. The following points need to be considered in selecting a design of piling for any work:

WATER-TIGHTNESS.—In deep cofferdams a prime requisite is water-tightness. The clearance of interlock of adjoining piles must therefore be reduced as much as possible to still allow of driving. The clearances used on the built-up types are from ⅛-in. to ¼-in. all around the interlock. In hard soils ¼-in. is none too much. In many sections of piling over 15 ft. or 20 ft. long there will be found such kinks and crimps, partly the result of handling on and off cars, that driving with a tight interlock is a serious problem. With such a close interlock, piles not true or perfect in alinement often refuse to drive when there is encountered a stratum of hardpan or layer of small boulders. Under such conditions piling often refuses under the heaviest drop or steam hammer. If driving is persisted in it will result in the crippling of the pile either at the top or bottom. Crippling at the bottom means usually an escape from the interlock and a curving to one side exactly like a clinched nail except that the curve of the clinch may have several feet radius.

STIFFNESS.—In locations where there are encountered strata of hard material such as often occur in river valleys, where the drift has been eroded and redeposited, the steel piling to be a success must possess considerable stiffness laterally to prevent crippling. Therefore examine the radius of gyration of the proposed section of piling. It is the writer's experience that for hard driving the free or unengaged edge (see X in No. 3, Fig. 1) of the pile being driven should be of a width (at right angles to the web) of one-third to one-half of the width of the engaged web (see Y in section No. 3, Fig. 1).

METHODS OF DRIVING.—The friction of long lengths of steel piling, with their inevitable crimps, will make necessary a heavy hammer, say a 4,500-lb. ram on a steam rig or a 3,000-lb. or heavier drop hammer. Most of the writer's experience in driving steel sheeting has been with the heaviest No. 1 Vulcan steam hammer (4,500-lb. ram); total weight of hammer resting on the pile, 10,000 lbs. These hammers are adjusted to strike about 65 times per minute with 3½-ft. stroke. These large (No. 1) Vulcan hammers are preferably fitted with a "McDermid base" consisting of a 1⅝-in. circular steel plate about 13 ins. diameter. These plates are slipped into a slot in the base of the hammer housing and receive the blow of the ram. The wood striking block or cushion is set into the heavy cast-iron follower on the pile and projects up into the socket of the hammer housing so that the McDermid base plate rests directly on the wood block. These wood blocks are made about 20 ins. long, 15 ins. diameter at center, and hewed to about 12 ins. at top and bottom to enter respectively the hammer housing and the follower.

In driving through hard clay layers, or when the piling is bound slightly by crimps in the interlock, the blows of such a hammer may run as many as 30 to 60 to the inch of penetration on such driving. In hard driving, one or two fresh blocks per 30 ft. pile are often required. The time consumed in stopping and changing blocks is from two to five minutes, provided the block is not badly split and wedged in. It is necessary to watch the failure of these blocks closely, as with a crushed or broomed block the efficiency of the hammer is very low. Therefore the blocks are removed as soon as they show signs of failure. The crushing usually takes place toward the middle of the length of the block, making a hot, steaming pulp of the tough oak or maple fiber for a length of 3 or 5 ins. Partially seasoned swamp oak, rock maple and blue gum have given the writer the best service.

The form of cast-iron follower used with steel piling, and shown in Fig. 2, was designed by the writer, and patterns are owned by the Vulcan Iron Works, Chicago, Ill., and the Jarvis Engine & Machine Works, Lansing, Mich. Fig. 3 shows a steel pile being driven fitted with the cast-iron follower and the spindle-shaped follower block above described. Flat-base followers are sometimes used, but do not hold the steel pile in position.

PROCESS OF DRIVING.—In driving steel sheet piling, if the alternate sections are light and heavy (that is, the heavy piles having double webs or double "I" bars), drive first a heavy section. Go slowly and take great care to have the initial pile plumb and exactly in position. Then interlock a light section with the first one driven. On account of time consumed in cutting off steel sheeting weighing 30 lbs. to 54 lbs. per sq. ft., it is always desirable to back the driver away from the work. In close quarters approaching a wall, or in the end of a deep cut for a core wall, for instance, this is not always practicable. In starting small cofferdams, as for piers or foundations on buildings where close adherence to line is required, one of the manufacturers of piling recommends that temporary piles about 4 ft. long be driven and taken out one at a time, and the long pieces of piling substituted, thus insuring starting correctly with the long piling.

Borings in casings are made along the proposed line of steel sheeting at say 25-ft. intervals, and the steel ordered to length accordingly. Except when encountering rock, boulders or extremely tenacious hardpan, the piles can usually be driven to a fairly uniform top level. When the objective foundation soil or rock bottom is in an eroded river valley which has again been refilled with drift, the hard bottom will frequently be covered with a generous strata of boulders which have dropped out of the eroded material because too heavy to be washed down stream. This boulder stratum is, of course, quite irregular and not so desirable a material in which to terminate sheet piling as a good clay or slightly disintegrated rock covering sound bedrock. Often too, sound bedrock is deeply channeled and filled with pot holes, so that piling may need some cutting, if it cannot be allowed to extend above grade, as into concrete.

The process of cutting steel piling by means of the electric arc was employed on the construction of the foundations for the New Hoffman House, Broadway and 25th St., New York City. The cost of cutting steel piling with current at 10 cts. per KW. and the attendant at 50 cts. per hour, is stated to be as follows per foot of piling cut: For current, $2.56; for labor, $0.40; total, $2.96. This is rather high, and the hack-saw would probably be cheaper. However, with current at say 3 cts. per KW.-hour the cost per foot would be but $1.17. Even at this rate, with labor competent to

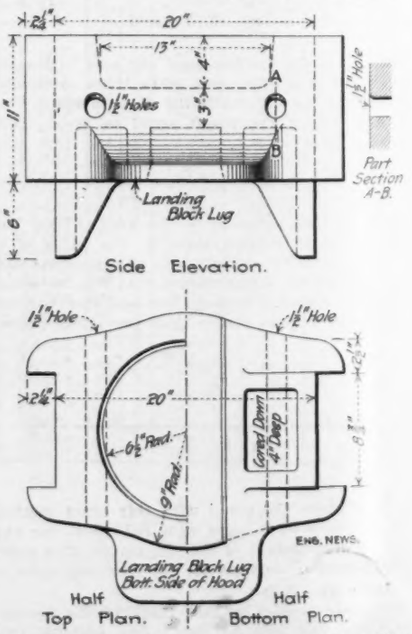


Fig. 2. Cast-Iron Follower for Driving Steel Piles.

THE PACIFIC EXTENSION OF THE MEXICAN CENTRAL RAILWAY.

One of the most important pieces of railway construction now in progress in Mexico is the last link in the new line of the Mexican Central Ry. to the Pacific coast, which will open up a new port and will give this railway system a line of communication between Tampico on the Atlantic (or Gulf) coast and Manzanillo on the Pacific. It is expected that the new line will be completed early in 1908. At present there is no railway communication with any Mexican port on the Pacific coast between Guaymas on the extreme north and Salina Cruz on the extreme south. For 30 years or more there have been numerous projects for lines to the Pacific coast, but the difficulties and expense involved in the crossing of the mountain range of the Sierra Madre, which lies close along the coast, have prevented any of these being carried out until now. More than 20 years ago a narrow gage line was started inland from the port of Manzanillo, by the Mexican National Construction Co., with the purpose of making a connection with the Mexican National Ry. Co.'s system. In 1889 it was completed as far as Colima, 59 miles (1,700 ft. above sea level), but financial difficulties and the great expense of building through the mountain range checked its further construction. This line was noted in our issue of July 5, 1894, while a complete description of the extensive works promoted by the Mexican government to establish a good harbor and shipping facilities at Manzanillo was given in our issue of Feb. 16, 1905.

The Mexican Central Ry. has for some years been gradually pushing forward a Pacific extension, and in 1905 the Mexican Pacific Ry. (in the interests of the Mexican Central Ry. Co.) purchased the Manzanillo and Colima line, thus making its objective point the port upon which the Mexican government has been spending large sums of money, as already noted. The Mexican Pacific Ry. Co. was bought by the Mexican Central Ry. Co. in 1905.

The Pacific extension leaves the main line between El Paso, Texas, and the city of Mexico at Irapuato, 219 miles north of Mexico, and runs westward to Guadalajara, 161 miles, and then south to Tuxpan, 120 miles further. The line to Guadalajara was built more than 20 years ago, and the extension to Manzanillo was authorized in 1902. The work now under construction is between Tuxpan and Colima, 42.16 miles, beyond which there will be some reconstruction of the old narrow-gage line to Manzanillo, 59 miles. The total distance from the city of Mexico to Manzanillo will be 600 miles, of which the last stretch of 100 miles is under construction. It is estimated that the line from Tuxpan to Manzanillo will cost the Mexican Central Ry. Co. about $11,000,000 (Mexican currency). The location of the line is shown on the accompanying map. For information as to the work we are indebted to Mr. Lewis Kingman, M. Am. Soc. C. E., Chief Engineer of the Mexican Central Ry.

The map also shows the relation of this Pacific extension to the Tampico Short Line, which is now being built by the Mexican Central Ry. from Apulco to Tampico, and which involves some very heavy construction work. This important line will reduce the distance between the city of Mexico and Tampico from 778 miles to 277 miles, and is to be completed in 1909. The distance by rail across the country from Manzanillo on the Pacific to Tampico on the Atlantic will be about 950 miles by way of the present line through Aguascalientes and San Luis Potosi; while by way of the city of Mexico and Apulco it will be about 875 miles.

The elevation above sea level at Irapuato, the beginning of the Pacific extension, is 5,554 ft.; and at Guadalajara it is 5,551 ft. At present the line between these points has grades that were fitted to the natural surface. The maximum is a grade of 1.25% from Yurecuaro to Pati, 13.2 miles, and there are several stretches of 1% grades. It is proposed to reduce all these (in the distance of 161 miles) to a maximum of 0.5%, with maximum curves of 6°, which can be done at a very reasonable cost. From Guadalajara to Quemada, 87 miles, there is a maximum grade of 1%, and beyond this is a pusher grade of 3% for four miles, which saved the company more than $1,000,000 as compared with the cost of a line having a 1½% grade.

This pusher grade takes the line up to the crest or Sayula divide on the Mexican mesa or plateau, at an elevation of 5,120 ft. The line then descends to Zapotlan, 10 miles, on a 1% grade. This is the new division point, where shops are to be located, and is at an elevation of 4,973 ft. From Zapotlan it is only about three miles to the secondary or Zapotlan divide, which is 36 ft. lower than the Sayula divide and is reached by a 1% grade. Beyond this there is a maximum descending grade of 2% for 65 miles to Coquimatlan, with the exception of two miles of 2% adverse grade in getting out of the Carpintero barranca or canyon. From Coquimatlan to Manzanillo there are 51.5 miles of 1% descending grade to Manzanillo.

Having given a general description of this important line, we may turn to that part between Tuxpan and the coast, where construction is now in progress to Colima, 42.16 miles, beyond which will be the improvement and reconstruction of the old narrow gage line for 58.90 miles to Manzanillo. From Tuxpan to Colima the line is located with a grade of 2%, compensated for curvature. The maximum curvature is 6°, with chords of 20 meters (65.6 ft.); this is equal to a curve of 9° measured by 100-ft. chords. From Quito, the present end of the track, there are 1¼ miles of level grade down the valley, but with some very heavy work. For Kilo. 199 the cost was $140,695; Kilo. 201, $130,773; Kilo. 204, $147,000; Kilo. 205, not yet completed, has already cost $146,967, and Kilo. 206 will probably cost $300,000. These figures are in Mexican currency.

MAP OF THE SOUTHERN PORTION OF THE MEXICAN CENTRAL RY., SHOWING THE PACIFIC EXTENSION TO MANZANILLO, AND THE SHORT LINE TO TAMPICO.

The first stretch of 4.34 miles of the line from Tuxpan was finished three years ago, leaving 37.82 miles now to be finished beyond Quito. In this distance are included 12 tunnels and 12 high bridges. The highest bridge is the Santa Rosa, which is 279 ft. above the bottom of the barranca. Nearly all of the tunnels will have to be lined. The walls will be of rubble masonry and the arches of cement concrete blocks. This style of tunnel lining was described and illustrated in our issue of July 26, 1906.

In making a trip from Tuxpan to Colima, which takes two days steady traveling by the trail, the first object of interest would be Tunnel No. 1, which was finished three years ago. This tunnel was in soft material which rained down from the Colima volcano. As late as 1903, construction work was temporarily abandoned owing to eruptions and earthquakes here. When building this tunnel there was found 4.92 ft. of soft brown sand below the proposed foundation, and it became necessary to put in an invert of concrete to hold the bottom down. This tunnel is 820 ft. long, and is lined throughout with concrete. The invert and sides are of concrete deposited in place; the arch is of concrete blocks, weighing 108 lbs. each, as noted above. From the further end of the tunnel it is only about 100 ft. to the abutment of the first bridge crossing the Tuxpan River. This bridge has two deck spans of 125 ft., and the track is laid beyond it to Quito, the first station below Tuxpan, on Kilo. 199 (Mile 123). Here the contractors have a forwarding house, telephone, and a stable for horses, and another house in which cement is stored and sacked for the "arrieros" who pack the cement to the work under construction all the way from Quito to a point 25 miles distant by the trail. There is sufficient roadway completed to make it a very easy mule ride down to Tunnel No. 2, which tunnel is about 262 ft. long, and is entirely finished. The side walls are of rubble masonry, and the arch of concrete blocks. This tunnel is dry, and the foundation is of rock, making the tunnel perfectly safe. From Tunnel No. 2 the contractors' trail runs up over the mountain and down again to the west end of Tunnel No. 3.

In the gorge, nature has been very active in tearing things out and deepening the channel of the river, causing the land to slide from the mountain into the river. This is not ancient history. The Atenquique barranca and the Tuxpan River got on a "tear" on Oct. 3, 1906, and the river carried down trees, brush and driftwood of all sorts and descriptions. The Atenquique Canyon (or barranca) is five or six miles long, and possesses many prongs extending up the mountain sides like the fingers of a man's hand. There were thousands of cloud-bursts, or waterspouts, which fell on the mountain sides in this drainage area, tearing out rocks, washing away the earth, and sweeping trees and brush and everything else into the boiling mass of mixed material to the river. The trees were rooted out of place; limbs broken off and the roots worn off and ground to pieces before reaching the Tuxpan River. They came down from the mountain side mixed with rocks, all the way from the size of a hen's egg and coarse gravel to some blocks that weighed 200 tons.

This debris dammed up the valley of the Tuxpan River for about 65 ft. on the north side, and 45 ft. on the south side. It came down the Atenquique barranca so quickly that the stones were carried fully 1,000 ft. up the stream against the current of the Tuxpan River. This would indicate that the slide occupied but a few minutes, before the water of the Tuxpan River had time to check the debris from the barranca. This dammed the Tuxpan River, backed the water up the river, or checked the current until the water rose at Tunnel No. 1 and on to the sides of the deck bridge across the Tuxpan River. When the current again set down the river it took the two spans out from the abutments and the piers, shearing off the anchor bolts smoothly. The water came to within about 13 ft. of the grade line. A new through bridge has now been ordered, and will be entirely safe from any future high water. It is interesting to see the drift lodged in the branches of the trees 60 ft. above the low water mark. The highest rise was opposite the Atenquique barranca.

Opposite Tunnel No. 3, this flood deepened the channel of the river 30 ft. or more. About 400 ft. east of this tunnel was a through cut 49.2 ft. deep on the upper and 23 to 26.25 ft. deep on the lower side; here some Mexican laborers had been making the concrete blocks for the tunnel lining, and had a tent in which seven people

lived. The stones came down like a sand blast in the river, and swept away the entire cut and the seven people. About the same time there was a landslide at the east end of the tunnel, extending 400 or 500 ft. up the mountain side, and 300 or 400 ft. along the line. Some blocks of stone 50 ft. long, and 30 or 40 ft. on a side, went into the river, and laid there until the current took the smaller ones away.

It became necessary to abandon the original line, with 288.64 ft. of finished tunnel and 393.60 ft. that had been taken out but not lined. The west end was all right and could be approached, but the east end pointed out into the river and was under a dangerous sliding mass of rock. A new location was made, throwing the tunnel above the slide into the solid rock of the mountain and making the new tunnel 1,354.64 ft. long. This is being worked on six faces, and is expected to be finished in six months.

As the line is completed above and below this tunnel, the contractors built a line around the point of the hill opposite the tunnel, using 18° curves on 20-meter chords, so as to get past this by the first of March. As soon as this tunnel can be passed, the track will be laid and the bridges on Kilo. 209 and 211 will be put in. These are deck bridges, and will be placed by a crane on a derrick car.

Tunnel No. 4 (Kilo. 214) is 288.60 ft. long and it has been lined, the sides with rubble masonry and the arch with concrete blocks. On Kilo. 218 the line crosses the Tuxpan River the second time. The bridge is a deck span of 370 ft. with a 50-ft. plate girder at each end; it is 197 ft. above the bottom of the river. The sides of the canyon at this point are of solid conglomerate rock. It is expected that this bridge will be erected in May and June. Meanwhile the river cannot be crossed here, and the mule trail winds along the sides of the valley and passes over a table land, coming down to the canyon again opposite Kilo. 220. Here it crosses the river and follows the line for about 1½ miles, back towards the river, crossing up-stream and passing under a cliff where the trail is 125 ft. above the grade line, and the river 200 ft. below it. There are all kinds of rock formation. Much of it is conglomerate, very loosely cemented together, and above the conglomerate is a flow of volcanic black rock, capping the whole cliff. On this work the men are let down by ropes and frequently tied on the side of the cliff where they are working. Not long ago a cow came along on the top, and in looking over, fell over, hitting a workman and killing him instantly. Along the canyon were found many streams of clear, pure water, and occasionally a spring. The sides of the valley and the barrancas are timbered; the trail is often shaded; there are flowers and tropical plants, vines and creepers, orchids, plums and berries.

Tunnel No. 7 (Kilo. 223) is 656 ft. long, and will have to be lined throughout. Between Tunnel Nos. 7 and 8 the line crosses the Cachipehuale barranca by a trestle bridge 190 ft. long and 112 ft. deep. Tunnel No. 8 is 262.4 ft. long, and No. 8½ (on Kilo. 226) is 1,371 ft. long; both of these will have to be lined throughout. On the side of the mountain the contractors have built a very narrow crooked trail, but reasonably safe, climbing up several hundred feet and then descending again to the Queseria barranca, on the south side of which is a very steep trail. The Queseria bridge is 492 ft. long and 204 ft. above the bottom. The longest span is 287 ft. Then there is a trestle with a span 75 ft. long between it and the main span, and a 40-ft. girder span at the west end of the bridge.

Tunnel No. 9 is 213 ft. long and will have to be lined. On Kilo. 230 the line crosses the Las Yugas barranca by a bridge 379 ft. long and 191 ft. above the bottom of the barranca; it has one span 177 ft. long, and the balance is trestle work. On Kilo. 231, the line crosses the Santa Rosa barranca by the highest bridge on the line, 279 ft. above the bottom of the barranca. It is a cantilever; the longest span being 154 ft., and is to be erected without falsework. A part of this bridge is to be shipped by way of Tampico and then by rail to Tuxpan; the other part of it will be sent around Cape Horn to Manzanillo, and up the line by Colima. It is expected to get the parts of this bridge united sometime during this year.

Tunnel No. 10 is 525 ft. long; No. 11 is 689 ft. long and on a 6° curve. No. 12 is 262 ft. long. All these will have to be lined with third-class masonry and concrete blocks. On Kilo. 237 is the Carpintero barranca; the longest span of this bridge is 230 ft., with a total length of 391 ft. It is 170 ft. above the bottom of the barranca. After crossing the Carpintero barranca the line passes over a very pretty country, somewhat of a prairie character, with rice fields and pasture lands on either side of the line, and plenty of water for irrigation. The line then crosses the barrancas of San Joaquin, Los Canos and Estancia, which are quite deep but require only comparatively small bridges.

The general contractors are Hampson & Smith, of the city of Mexico. The Missouri Valley Bridge & Iron Co., of Leavenworth, Kan., has the contract for the erection of the bridges on this line. There are nearly 7,000,000 lbs. of steel work in all the bridges between Tuxpan and Manzanillo. All of the bridges are on tangents, at least none of the long spans are on curves, and all of the bridges except one are deck bridges with sidewalks and hand rails. There are no piers in any of the river or barranca crossings; it would not be safe to put them in the way of such floods as are experienced in these streams.

The division engineers on heavy work have six kilometers (or about four miles) of line. It requires considerable strength to ride over the line and considerable nerve to climb the cliffs and make the crossings of the barrancas. The trails are narrow, on almost vertical sides of the cliffs. The engineering work on this line has been in progress for six years. Mr. C. W. Curry located the first line from Tuxpan down to Colima, and was employed about 18 months on the work. Later Mr. O. G. Bunsen re-located the line and spent about three years on the work. Mr. Edward Wright was division engineer on the first division below Tuxpan, including the first tunnel. He completed this three years ago. The work was then discontinued for about two years. Then Mr. Donald D. Colvin was given the second division from Kilo. 199 to 205, inclusive. He has been on this division since June, 1905, and expects to have the work completed in September. Mr. Edward Wright took the third division of 11 kilometers in June, 1905, and expects to have this completed by April. Mr. R. S. Cumming took the fourth division of five kilometers. Mr. C. P. Webber commenced on the next division (18 kilometers) in July, 1905. Mr. Wm. M. Myers took the sixth division (7 kilometers) in July, 1905; he resigned in October, 1906, and Mr. E. R. de Steguer took his place; this division will be completed in July, 1907. Mr. J. C. Galbreath has the seventh division (12 kilometers) and this should be done by April. Mr. W. T. Carley took the eighth division from Kilo. 249 to 360, at Colima. He resigned in November and Mr. J. C. Galbreath finished the division.

The division engineers are provided with tents, have Chinese cooks, and board themselves very comfortably. They are furnished with horses to ride over their divisions, and to send for men and go on errands. The railway company and the contractors have built a telephone line connecting their offices at Tuxpan and the different camps along the line, including some of the engineers' camps, as far as Kilo. 236. This telephone line has been very convenient, especially so owing to the very rough nature of the country. It is now being extended to Colima.

Below Colima, 20 miles of the narrow-gage line has been changed and placed under contract. This line has been subject to washouts from high water in the Armeria River, and in October last the river rose higher than it was ever known before, so that this part of the line must be rebuilt to make it safe. After the flood the line had to be relocated and placed on higher ground. It is the intention now to keep 13.12 ft. above the high water of Oct. 3, 1906, at all points. The Armeria bridge, which will consist of one span of 210 ft., and five spans of 130 ft., will also be 13.12 ft. above the high-water mark. At Jala Point, 14.26 miles below Colima, the line was entirely washed out and no remnant left; here it became necessary to build a tunnel 1,050 ft. long, which goes directly through the point instead of around it. There is another heavy point at 10 miles below Colima. From Manzanillo for 51 miles eastward towards Colima there is a 1% grade, and a maximum curvature of 6°. From that point to Colima the grade is 1.75%, with light curvature.

The narrow-gage line was washed out for a distance of 7½ miles by the flood of Oct. 3, 1906. During the last four months a temporary grade in the bed of the river has been made and material picked up and the track relaid on this part of the line, so that trains commenced running Jan. 25, 1907. It is expected to keep the line open for traffic and for the convenience of construction on the new line until the rainy season, when the line is sure to be again washed out, and made entirely useless for three or four months. It is not expected to have the change of this portion of the line completed before December, 1907.

At Manzanillo the company has built a wharf 490 ft. long and 73 ft. wide, of creosoted piles, with a track on either side. This is to be extended 210 ft. further. There is a depth of 30 ft. of water at the end, and 15 ft. at the seawall. There are layers of coral rock extending over a large portion of the harbor; but creosoted piles can be easily driven through these layers of rock. There is room for several ships to anchor in the harbor, but the government is now considering the question of an inner harbor to obtain more room to do the business of the port and to secure more safety to the shipping. The harbor works were described in our issue of Feb. 16, 1905.

Owing to the fact that the high hills lining the coast leave but little available room between the hills and the shore, the railway company has located the terminal station and a freight station two miles from Manzanillo, and is building employees' cottages, the necessary terminal facilities, switching yards and other conveniences. A good water supply will be obtained and the railway employees in the new town of Manzanillo will be well provided for. The shops for this division will be at Zapotlan, at an elevation of 4,973 ft. above sea level, where the climatic conditions are excellent and there is no malarial fever.

Tuxpan has a very healthy climate, and it is quite healthy for 12½ miles below that point, but below that there is considerable malaria. There are rice fields, and irrigated lands on the plateau above the canyon. On this part of the line the contractors very frequently have 12% of all their employees sick with malarial fever. From Colima to Manzanillo the climate is more or less sickly; it is hard to realize this, as the days are pleasant, the air is dry, and there seems to be the most favorable climatic conditions, but the senses are not to be relied on. There is a large lagoon or lake on the line near Manzanillo, which at times is nearly dry, and then the health conditions are very bad.

STEAM AND ELECTRIC TRACTION are both operated on the lines of the Evansville, Suburban & Newburgh Ry., running out of Evansville, Ind. The first portion of the line was built in 1888 and was operated by "dummy" locomotives until 1905, when electric traction was adopted under a state law of 1903 permitting steam roads to make this change, while a later law (1905) allows roads which have made the change to use both systems of motive power. The road has 28 miles of main line, built on private right-of-way. It has passenger and combination passenger and baggage electric cars, 46 ft. long; also an electric express car. There are also three "dummy" or enclosed locomotives with cylinders 10 × 14 ins., 12 passenger cars and 32 gondola and box freight cars; a larger locomotive and a number of gondola coal cars are to be added, as the line serves a number of coal mines. The steam equipment is only used for passenger service at times of exceptional crowds. Formerly there were five steam trains each way per day, making the trip in 45 minutes; now there are 11 electric trains per day, making the trip in 28 minutes. The traffic has increased about 40% since the introduction of electric traction.

A CENTER-BEARING DRAWBRIDGE WITH PNEUMATIC RAISING JACK AND TURNING ENGINE.

A drawbridge recently completed in the city of Hamburg, Germany, crossing the Oberhafen, is operated by machinery of very novel kind. The source of power for all the motions is compressed air, which is supplied by a small gasoline-engine compressor on the bridge charging a battery of high-pressure air storage tanks. This is the first case, so far as we know, where air power is employed for operating a movable bridge. A further feature of the machinery is the use of the lifting jack under the center pivot for raising the bridge off its supports preparatory to turning; this is novel only in using compressed air for the lifting, as hydraulic-jack center pivots have repeatedly been constructed. The lifting pivot construction requires, of course, that the bridge be a thorough center-bearing span, and accordingly the pivot is so detailed as to be able to steady the bridge against tipping while swinging. We take the drawings reproduced herewith and the text data from the "Zeitschrift für Bauwesen," where this interesting structure is described at some length.

The bridge, of which the drawspan is a part, is a double-deck structure. The upper deck carries four railway tracks on a solid floor; the lower deck has a roadway and two footways. The drawspan, designed to provide for two channel openings of 47.9 ft. each, has a span of 154.8 ft. Like the other spans of the bridge, it has two trusses, parallel-chord Warren girders spaced 28.2 ft. apart c. to c. The structure is unusually heavy, the drawspan alone weighing nearly 1,100 tons. Fig. 1 herewith is a cross-section of the drawspan at the center pier, from which the arrangement of the two floors in relation to the trusses may be seen.

The bridge was made the subject of a limited competition for plans, and subsequently of a final competition between the two leading competitors. In the final competition the authorities (the Prussian Government) specified the general type of operating machinery to be used, not having found the competitive plans to be satisfactory in the matter of machinery. The bridge is in a location where it will have to be opened only infrequently. For this reason operating machinery of large continuous capacity or having a large running cost would not be warranted. At the same time, the heavy traffic over the bridge makes it necessary to open and close the bridge rapidly, which involves large power output in the operating machinery during the time of turning. The government engineers concluded that these two requirements—large power capacity for a short time, and small plant, or small continuous capacity—pointed to a storage system; and they decided in favor of a compressed air system with high-pressure storage, and a small charging engine, which, working nearly continuously, would supply through the storage tanks the energy required for moving the bridge.

The machinery designed on the basis of this idea comprises a pneumatic (or rather an air-hydraulic) jack under the center pivot for lifting the bridge off its end bearings, a compressed air turning engine, compressed air end latches, and minor auxiliaries. Air is supplied by a gasoline-engine-driven compressor of 12 HP., running at 200 r. p. m., producing air at 1,700 lbs. per sq. in., with a capacity of about 8.8 cu. ft. (compressed volume) per hour. This air is ...ed in a battery of 28 steel containers, each ...ut 8 ins. in diameter by 17½ ft. long, wi... an aggregate capacity of 140 cu. ft. From ...re it goes to the power devices by way of a re-ducing valve, which brings the pressure ...wn to 680 lbs. per sq. in. The stored air ca... be drawn down to about 850 lbs. pressure.

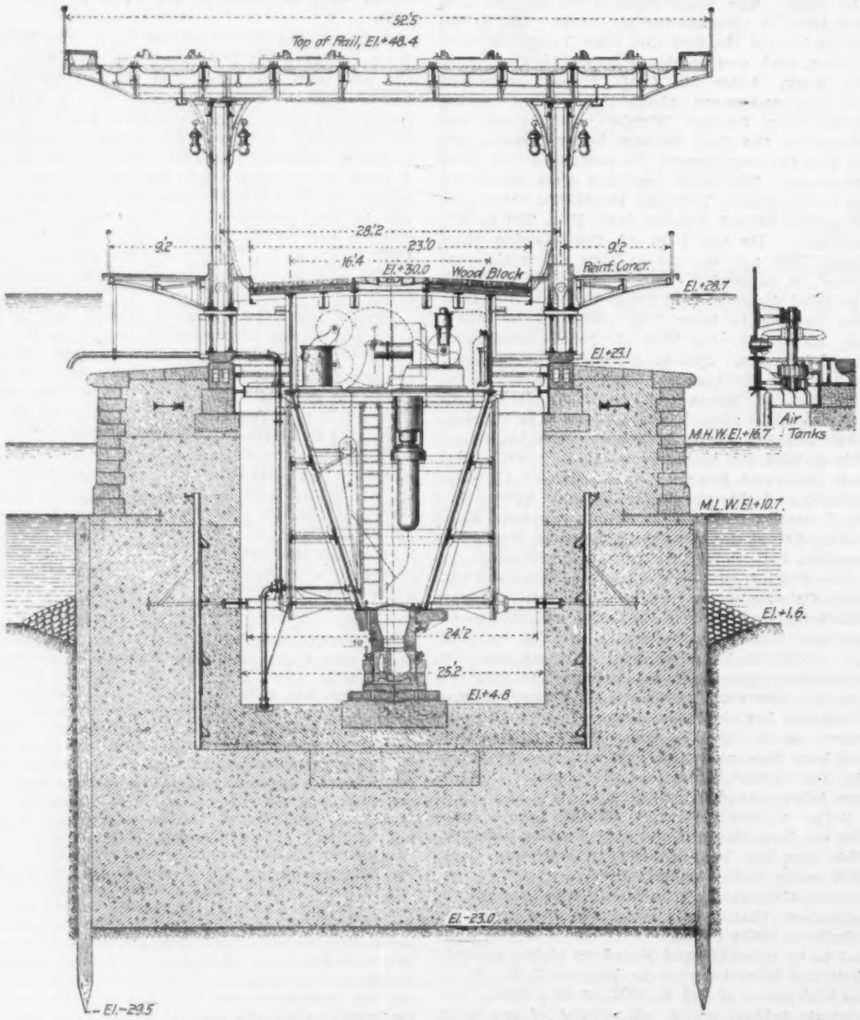


FIG. 1. CROSS-SECTION THROUGH PIVOT PIER OF DRAW SPAN, OBERHAFEN BRIDGE IN HAMBURG, GERMANY.

The structure of the supporting pivot at ...he center of the bridge and arrangement of ...he lifting jack are shown in Fig. 1. The center pier of concrete is built with a deep pit in the middle. The lifting jack is seated on the floor of this pit. From the upper surface of the ram rises a conical or pyramidal column of riveted steel work. The center floorbeams of the bridge and two longitudinal bearing girders between these floorbeams rest directly on the top of this column. The square space enclosed by these four girders below the roadway floor is the engine room. As the drawing also shows, when the bridge is closed and is down on its end bearings it rests on two central supports on the center pier, one under each truss at exactly mid-span. When the bridge is raised by the lifting jack below the center pivot, these supports are not in bearing and the structure therefore requires steadying while it is turning. For this purpose there are two ring-shaped guides surrounding the central column support, at top and bottom of this column, respectively, 17.3 ft. apart vertically. Each of these rings is engaged by four segmental shoes attached to the column, the lower shoes being carried on a system of bracing built out from the column. Shoes as well as guide rings are of brass. A turning rack is fastened to the walls of the pit near the level of the upper guide ring. The small detail section in Fig. 1 shows the approximate position of the rack and manner of driving the rack pinions.

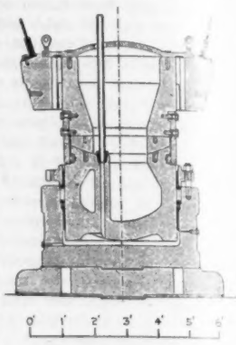


Fig. 2. Raising Jack Under Center Pivot, Oberhafen Bridge. Spherical Adjusting Plate in Ram to Keep Lateral Stresses Out of Jack.

The lifting jack is shown in more detail in Fig. 2. It requires a pressure of about 1,700 lbs. per sq. in., which is just the same as the maximum pressure. To enable the stored air to be used over a considerable range of pressure, the before-mentioned reducing-valve is employed, and an intensifier is provided in the air line between the storage tanks and the jack. This intensifier is not particularly novel in its construction, but to make the arrangement a little clearer it is shown in Fig. 3. The air enters the intensifier from the storage tanks at the top by way of the reducing-valve, at 680 lbs. pressure, and as the ratio of the intensifier is 1:2½, a pressure of 1,700 lbs. per sq. in. is produced in the lower cylinder. Over the plunger of the power side of the intensifier there is a deep layer of oil, in order to prevent all leakage and at the same time lubricate the plunger. Oil is used similarly on the delivery side, but, as the volume here is unchanging and the connections direct, the oil fills the entire space of the delivery cylinder, connecting pipes and lifting jack, so that the lifting jack and the delivery side of the intensifier are virtually hydraulic. In general, the method of packing by oil is carried out in all parts of the pneumatic machinery of this bridge, even in the operating valves.

The bridge is raised about 4 ins. at the jack. The amount of this motion is defined by the possible length of stroke of the intensifier plungers. It requires about 28 to 30 seconds to lift the bridge, and about 25 seconds to lower it. The speed of lowering is controlled by a throttling passage in the connecting pipe between the jack and the bottom cylinder of the intensifier.

A three-cylinder air engine, with plunger pistons whose rods work on a common crank pin, drives the turning gear of the bridge. The engine is 37 HP. output at 700 r. p. m., supplied with air at 425 lbs. per sq. in., the normal maximum. It is possible to control the pressure applied to the engine between zero and 565 lbs. per sq. in. The engine is further controlled by a speed governor in order to prevent too great a speed of turning under all circumstances. The throttle valve actuated by this speed governor is also used in conjunction with a limit stop, to bring the bridge to rest at the end of its 90° motion in opening or closing. A set of dogs is arranged on the concave face of the center-pier pit, and these dogs are adapted to strike levers projecting from the engine-room, which when the bridge is nearly opened or nearly closed, shut off the throttle valve so as to leave only a very minute passage through which air can be supplied to the engine. The power and speed of the turning is thereby reduced so that the pneumatic buffers of the bridge are able to absorb the residual energy.

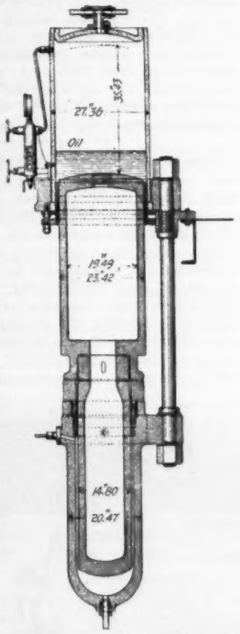


Fig. 3. Air-Hydraulic Accumulator Supplying Raising Jack, Oberhafen Bridge.

Several features of the turning mechanism may be noted. The air engine is surrounded by a water-filled box, with the object of equalizing its temperature so as to prevent freezing up of the valves from the cooling action of the expanding air. Auxiliary to the engine is a starting jack, operated by air, to relieve the engine of the heavy duty of accelerating the bridge. The ratchet wheel on the first gear shaft is engaged by pawls, or dogs, on the plunger rod of a pneumatic jack. This jack is automatically thrown into operation when air is admitted to the engine, and is thrown out of action automatically when the bridge has turned a certain distance. The turning engine always runs in the same direction. Its pinion drives two gear shafts, for forward and reverse motion, respectively; each of these shafts is in two parts, connected by friction coupling and fitted with brake disks.

The pneumatic buffer which is fitted at one end of the bridge has already been mentioned. This buffer, striking a fixed stop on the pier masonry (or for the open position a similar stop on a cluster of piles in the river), is compressed, and on recovery forces back the bridge, which meanwhile has overrun its proper position. In the case of closure of the bridge, this brings the structure into exact position for latching.

There is a latch at one end of the bridge only—the south end. It is a rectangular bar moving in guides on the center line of the bridge, operated by an air cylinder and adapted to enter a socket, or lock-plate, on the abutment. The lock-plate is so formed that the latch may remain in engage while the bridge is being raised or lowered; the latch is withdrawn only after the bridge is raised, and in the reverse operation of closing, the latch bolt is shot before beginning to lower the bridge, in order that it may serve as a guide. While this latch ensures the suitable alinement of the rails at the south end of the bridge, it does not answer for the north end, and the designers of the structure, fearing that one-sided expansion or other causes might lead to trouble in the alinement of the north rail ends, made separate provision for these. A latch is there provided, very similar to the main latch except that its latch-bar is jointed and the outer portion does not move in fixed guides. Connected by cross-bars to this outer portion are the ends of the eight bridge rails. A length of about 8 ft. of each rail is loose and turns on a vertical pivot at its inner end. As the jointed latch-bolt moves forward to engage a lock-plate on the abutment, the wedge-shaped end of the bolt guides the bolt into central engagement, and in doing so the bolt draws the pivoted rail ends over into exact alinement with the rails on the abutment.

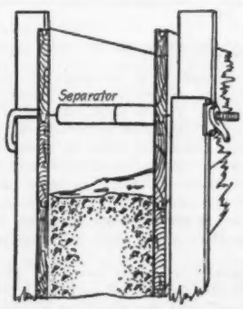
Auxiliary to the main machinery are, first, a special high-pressure air-pump, which may be connected to the gasoline engine for direct pumping into the lifting jack, in case the supply by way of the intensifier should fail; second, a hand pump for operating the latches and the signal coupling; third, means for coupling the gasoline engine direct to the turning gear; and finally, special gearing for doing both the lifting and turning by hand. There is also a centrifugal drainage pump for keeping the pivot pit dry.

The machinery has been found very satisfactory. The regular operating devices accomplish a 90° rotation in 75 seconds, or the complete cycle of lift, unlatch, turn, close, latch, lower, in 4½ minutes. When the compressed air storage is out of service and direct pumping from the engine is employed, the cycle requires 17½ minutes, and with hand operation it requires two hours.

The construction of this bridge was done by the following concerns: Substructure, F. H. Schmidt, of Altona; Superstructure, J. C. Harkort Bridge Company, of Duisburg; Machinery, Haniel & Lueg, of Düsseldorf, and the L. Schwartzkopff Company, of Berlin. The work was ordered by and in charge of the Prussian Public Works department. The contract price for superstructure and machinery was about $220,000.

A CONCRETE FORM SEPARATOR.

The usual system of holding wall forms apart in reinforced concrete work is either by the use of bolts or wires for tension, using wooden blocks for struts, or by enclosing a bolt in an iron pipe, which latter acts as a strut. In all of these methods either the bolt, wire or pipe is left in the concrete to protrude from the finished face and cause unsightly stains, or else the iron must be cut back from the face at great trouble and expense and the surface hole filled with mortar. As an improvement on these devices, Mr. Wm. T. McCarthy, 1 Madison Ave., New York City, has patented a special separator, molded of cement mortar into the shape of an ordinary pipe. This comes in 4-in. and 6-in. lengths and is placed between the forms, as shown in the accompanying figure. When the forms are to be taken down, the bolt is drawn and the pipe left in place, its hollow opening being closed with mortar. As it is of the same material as the mass work there will be no danger of stains or discolorations.



CEMENT PRODUCTION IN THE UNITED STATES for the calendar year 1906 has just been reported on by the U. S. Geological Survey, as follows:

The total production of all kinds of hydraulic cement in 1906, including Portland, natural-rock and Puzzolan cements was 50,027,321 bbls., valued at $54,015,713. Of the above total amount of cement manufactured in the United States in 1906, 45,610,822 bbls. were Portland cement, with a value of $51,240,652; 3,935,275 bbls. were natural-rock cement, with a value of $2,362,140; and 481,224 bbls. were Puzzolan cement, valued at $412,921. Prices were good in 1906, and showed an advance over those of 1905. The total production of cement in 1905 was 40,894,308 bbls., valued at $36,012,189. Comparison of totals for 1905 and 1906 shows an increase in 1906 of 9,133,013 bbls. in production and $18,003,524 in value.

THE USE OF COPPER SULPHATE AT PAWTUCKET, R. I., TO PREVENT THE CLOGGING OF SEWAGE FILTER BEDS BY BLANKET GROWTH OF MICRO-ORGANISMS.*

The regular monthly or bi-monthly examination of the work of the sewage purification plants of the state is carried on by the board [State Board of Health] in conjunction with the local oversight of the plants by the city engineers or superintendents in charge of the same, the board also giving its laboratory facilities and the knowledge and experience of its chemists to the study of any plant which may get into difficulties. The city of Pawtucket, through its Board of Public Works, has been especially hearty in its cooperation with the State Board of Health, and the studies of the sewage problem, carried on by the city engineer, Mr. George A. Carpenter, and this board, have been productive of interesting results.

The history of sewage purification in Pawtucket has been similar to that in other places, in the same latitude, using sand filtration. Those beds which have shown high nitrification during the warmer months of the summer have shown a decreased nitrification as cold weather approached, and at times, while giving an effluent of fairly good appearance, still have shown practically no nitrification, but as soon as warmer weather came on, returned to their normal condition. The winter of 1905-6 was a mild one, and the Pawtucket beds maintained nitrification longer than in some winters; but instead of all the beds recovering from the effects of the winter, they continued to give poor nitrification, whereas in other years they had been restored to good condition, and were in a condition where they would stand with sewage on them not merely for hours, but for days before one could see the surface of the sand. Attention being called to this condition by City Engineer Carpenter, and the analyses indicating, as above stated, a poor nitrification, special work on the plant was begun, cooperating with the city engineer, to rectify the trouble if possible.

Examinations of sand in the beds for albuminoid ammonia showed a large accumulation of nitrogenous matter in the upper layers, the top 8 ins. of most of the beds showing quite high figures; and a tabulation of the strength of the sewage of other winters and summers showed that the winter of 1905-6 had given a very much stronger sewage than any previous period. It was assumed that this strong sewage, through the winter just passed, had clogged the beds in addition to the stored nitrogen of previous years, and that a removal of 6 to 8 ins. of sand and resurfacing with new sand might correct the difficulties. Accordingly the sand in two beds was removed to a depth of 6 ins. and new sand put on, the underdrainage system having been previously cleaned. At first, after nitrification had been established, conditions were quite a little better; but very soon these beds again showed a marked decrease in nitrification, finally reaching the point where little or none was obtained, and the surface of the beds soon presented the now familiar appearance of a large greenish-black deposit spread over the entire surface of the bed. This deposit had the appearance and consistency of a rubber mat, and was very tough, and impervious to water. After collecting on the beds it curled up when dry, in great quantities, as shown by Fig. 1. This necessitated very frequent scrapings in order to have the beds perform any work, for if it was allowed to remain there too long the whole bed became clogged and sewage stood on it to the depth of several inches, and it became necessary to put men onto the beds with spades to break through the deposit and open up the top of the sand and allow the sewage to work away through the beds. This condition is illustrated by Fig. 2. Both of these photographs are reproduced through the courtesy of Mr. Carpenter.

An examination of this black deposit showed it to be made up to a great extent of Oscillaria. It was now thought that the trouble might be due to this growth on the beds, and that if it were possible to kill this the conditions would improve. On Aug. 6, 1906, two beds were treated with 2 lbs. of copper sulphate to each bed (the area of each bed being about .18-acre). The copper salt was trailed through the sewage, which was held on the beds to a depth of approximately 6 ins., the outlet to the underdrains being closed. After this copper was all dissolved the beds were allowed to stand for about 48 hours. The sewage was then drained off through the bed and the operation repeated. At first it seemed as if the trouble had been somewhat relieved by this treatment, but very shortly the growth returned.

Realizing from albuminoid ammonia tests that the beds contained too much stored nitrogen for them to do the best work under any conditions, several other beds were scraped to a depth of 8 ins. and resurfaced with new sand, but the experience with these beds was similar to that with the two which had been used for experimental purposes.

During all this time, as has been the custom for a

*From the November-December Bulletin of the Rhode Island State Board of Health (Garder T. Swarts, M. D., Secretary, Providence, R. I.).

number of years, the sewage had been applied to the beds at the rate of 100,000 gals. per acre, and the dosing being on alternate days was at the rate of from 50,000 to 60,000 gals. per acre per day. Thinking that this rate of dosing was probably too much for the beds, considering the quantity and strength of the sewage, the dose was dropped to 25,000 gals. per acre per day on two of the beds which had been resurfaced, and a very satisfactory nitrification was established, but the growth of Oscillaria which had been present in the plant finally appeared on the beds again, although not to the same extent as previously.

A careful and thorough investigation of all the conditions at the plant, especially of the distributing system, showed the presence of a very large growth of Oscillaria, together with some Ulothrix and Cladaphora in the main distributer to the beds and the manholes in the same. This fact indicated that possibly the Oscillaria and other growths had been killed in the copper sulphate experiment, but the spores of the organisms had been carried from the distributer, through the conveyers, onto the beds, there to flourish and clog the surface again. No signs of these growths were found in the screen tanks, or settling tanks, so the problem now seemed to be to clean up the main distributer. Accordingly at the suggestion of the chemist of the board, Mr. Gilbert H. Pratt, who had also suggested the earlier copper sulphate experiment, this main distributer and the manholes were thoroughly scoured with steel brushes and then scrubbed with a solution of one part copper sulphate in 5,000 parts water. After this cleaning all sewage flowing onto the beds was dosed, just as it left the settling tank, with copper sulphate, one part in 50,000, for a period of 15 days. At the end of this time the method of operation of the plant was as before. The use of the copper solution was discontinued and the rate of dosing on some beds now being 50,000 gals. per acre per day, and on other beds 25,000 gals. per acre per day.

The nitrification of the plant was not injured in the slightest degree by the copper sulphate treatment; on the contrary the general condition in that respect, at the end of 15 days, was better than at the beginning, and after the plant had returned to its normal condition as to treatment, nitrification kept increasing and continues high up to the present time, January, 1907, when, judging from the experience of former years, one would not be surprised to have a low nitrification. The beds are now giving good results and effluents of good appearance, and the Oscillaria and other growths have ceased. Since the dosing of the sewage flow with copper sulphate there has been no delay in drying out the beds, and the deposits on the beds have been normal in quantity and in appearance. The only sign which has been seen of these growths has been in a location which furnishes a strong argument for the results which have been accomplished by the use of the copper sulphate. Some of the beds were furrowed when this dosing took place. This has been the custom in other years as fall approached. This was the case with the worst bed, from the standpoint of microscopic growths. A very marked green growth made its appearance on the top of the furrows on this bed above the "high water line" and remained for some little time but finally disappeared and did not spread to any great extent into the bed. The same phenomenon was noticed on one or two of the other beds which had not been furrowed, the growth showing on the banks at the edge of the grass just above where the dosed sewage reached.

As explaining why these small growths which appeared did not spread into the bed more, it is suggested by the chemist that the accumulated copper in the top layers of the bed may have exerted a strong enough toxic effect to have prevented this. This suggestion is in line with some experimental work carried on under the direction of the Massachusetts State Board of Health on the storage of copper in the sand of water filters, which showed that there was a very decided accumulation of copper in the top few inches of the sand of filters which had been treated with water containing copper sulphate.

To sum up the situation, drawing conclusions from points brought out in these remarks and from analyses which have not been presented here, one may conclude as follows: The sewage of Pawtucket, which, when screened and settled for a period of about four hours, contains normally in parts per 100,000 about 1 part of albuminoid ammonia, free ammonia of about 10 parts, suspended solids of about 20 parts, and about 10 parts oxygen consumed by the five-minute boiling test, had increased in strength and quantity during the winter of 1905-6 to such an extent that the limited filtering area and heavy dosing clogged the beds with stored nitrogen and fatty matters so that when the spores of the micro-organisms were carried onto the beds from the main distributer the conditions were most favorable for the production of a network which these growths soon formed. Had the beds been able to dry out quickly, the growth would probably not have secured such a hold on the beds as they did. Thus the strength of the sewage and the dose were the primary cause of the trouble. The micro-organisms may be regarded as the secondary and most crippling cause, for it was these that finally put the beds almost out of commission. Resurfacing the beds and watching the rate of dosing no doubt helped matters, but the main relief was obtained from cleaning the distributer with copper sulphate and the subsequent dosing of the sewage with the same. This is emphasized by the fact that beds that were not resurfaced improved greatly after the copper sulphate treatment with no material change in rate. A return of the bad conditions may be looked for, however, at any future time if extreme care is not exercised in the rate of dosing of the beds and changes made in the rates at which sewage is applied to the different beds when their action calls for lowering the same.

At Pawtucket this careful oversight has been provided for by the assignment of a special assistant engineer to keep in close touch with the plant and all conditions existing there as to quantity of sewage, strength of the same, condition of the beds, and to give instructions as to the rates at which sewage should be applied to the different beds. Since this assignment there have been several instances where a change in rate at the proper time gave improvement in the drying out of the bed and in the quality of the effluent. This should be borne in mind in connection with other plants, for a plant which would purify the sewage of a community several years ago cannot necessarily do it satisfactorily to-day with the same supervision, as the increased quantity and strength of the sewage on account of the natural increase in population may overtax the capacity of the plant as at Pawtucket.

This plant is now giving good results under unfavorable conditions as to season, while before the copper treatment, under the most favorable conditions of summer and early fall, the results were so poor that the plant was nearly out of commission at times. It is felt that these experiences may serve as a precedent for similar treatment with copper sulphate at some other place, or again at Pawtucket, if micro-organisms make their appearance, provided, of course, that this treatment be made with properly calculated doses and under expert supervision.

Fig. 1. Growth Curling Up.

Fig. 2. Breaking Through the Growth.

BLANKET GROWTHS OF MICRO-ORGANISMS ON SEWAGE FILTER BEDS AT PAWTUCKET, R. I.

THE "TWOPENNY TUBE" IN LONDON is not carrying the traffic which was expected of it at its inception. The Chairman of the Board of Directors recently announced that the present universal fare of twopence would probably have to be altered and a charge of one penny made for short distances. It was stated that in the last six months 1,000,000 passengers had been lost chiefly owing to the newer means of surface locomotion. The "London Engineer" in commenting on the situation says that the probable reason for this falling off is the immense popularity of the recently introduced motor omnibus service. The various omnibus services in London are carrying about 400,000 persons daily and since the motor service has been installed the number is increasing in greater proportion than ever before. The conditions in New York City, where the introduction of new systems has seemingly no effect on the number of passengers carried in the old, is in great contrast to the situation as reported from London.

THE SUPERIORITY OF STEEL CARS over wooden ones is strongly brought forth in a paper on "Repairs to Steel Freight Cars," read before the New England Railroad Club, by Mr. J. F. MacEnulty. Repairs to steel cars are usually easily made, as seldom any part of frame or body is lost in an accident, and injured parts can either be heated and straightened in place, or the rivets can be cut and, after straightening, the parts replaced at the cost of new rivets and labor. Car maintenance, it is estimated, is reduced 35% by the use of steel cars, while stock for repairs is reduced 50%. Regarding the cost of repairing 100,000-lb. capacity steel hopper cars, Mr. MacEnulty gives the following figures obtained from railroad systems using over 100,000 of these cars, many of which had been in use for seven or eight years.

One end having side and end sills, draft sills and corner braces and brackets badly bent.....	$36.50
Both ends damaged as above and body badly sprung	85.75
To cut entire frame and body apart and re-rivet..	140.00
A steel car having been in a wreck that would totally destroy the body and frame of a wooden car can be repaired as good as new, for.....	50.00
A steel hopper so badly wrecked that scrapping it was considered, was repaired good, for.....	160.00

This is the labor charge of cutting off the bent parts, straightening and re-riveting in place; the only new material used being rivets.

The average cost of repainting gondolas or hopper cars, not including the trucks, at one of the shops where some 500 cars are repainted per month, is stated as follows:

Sand blasting	$0.45
Paint for body and lettering.....	6.00
Labor for body and lettering	10.00

As illustrating the economy of steel cars and the fact that they are always worth repair, Mr. MacEnulty shows several damaged hopper cars, which look as if they were only suitable for scrap. These cars were, however, repaired and put in first-class order at a very moderate cost. Regarding the accident and repairs he says:

> These cars, each containing 50 tons of ore, ran three miles down a 4% grade on the Lake Champlain & Moriah R. R., an ore road in the northeastern part of New York, and with the engine jumped over the end of a switchback, the cars and engine going through the air 422 ft. before striking the ground; the point of contact was frozen ground, the drop being 53 ft. from the track level. The engine and cars then rolled 516 ft. These seven cars originally cost about $1,200 each. The cost of repairs averaged $890 each, which was the manufacturer's cost, and included 10% profit and an operating and administration expense that on a railroad would be largely taken care of in other operations, and not charged entirely to cars, as is necessary for a car builder. A large part of the cost was in the trucks, owing to the peculiar nature of the wreck. Eliminating the trucks, the repairs to the bodies cost only $350 each.

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We alluded last week to the possible work of the new Commission on Inland Waterways recently created by President Roosevelt, in investigating such matters as flood control, water storage for irrigation and power purposes. Undoubtedly, however, the first work of the commission and the one which most challenges public attention will be in relation to the Government's River and Harbor work.

What is needed more than anything else in the conduct of these works for the improvement of internal navigation is an intelligent and comprehensive PLAN. For these many years the Government has been spending enormous sums on river and harbor works without any plan whatever. Appropriations have been distributed not so much with regard to the fact that this particular harbor or that particular river were worthy of the expenditure upon them, but because the congressman of the district was after an appropriation for his constituents. None have realized the absurdities and enormous wastefulness of this system better than the able members of the Corps of Engineers who have been obliged to work under it. They are deserving of great credit, because they have been able notwithstanding these adverse conditions to checkmate many of the absurdities and frauds, so that for the most part the Government's money spent through this corps has been laid out to fair advantage.

It is high time, however, that a change was made. The routes for internal water-borne commerce should be improved and developed in an intelligent and systematic manner and not by the piecemeal system—or lack of system—that has ruled hitherto. The question must be studied, moreover, from the point of view of "What is worth while," and of what is worth while under modern transportation conditions.

The problem of internal waterway improvement is far different to-day from what it was thirty or forty years ago, when the railway was in the infancy of its development. The rivers were the first highways for transportation, the country over, and all through the West and South the steamboat went in advance of the railway. It was worth while to run steamboats in the days when ten tons was a full load for a freight car and a dozen such cars were a trainload; but steel rails and large capacity locomotives and cars have revolutionized the railway as a transportation machine.

It may be said that there is traffic enough for both the railway and the steamboat; but this is true only on main trunk lines. It must be remembered, too, that all over the Northern United States water transportation is stopped a good part of the year when the streams are closed by ice, so that water routes can at best be only a supplement to the railway system.

The more one studies the problem, the more convincing is the demonstration that the future development of water transportation routes should be for trunk line service where heavy traffic may reasonably be expected. It becomes less and less worth while every year to spend money on the smaller rivers, where a dwindling local traffic only is served.

If the commission can fully establish this principle in the minds of Congress and of the public, it will have rendered a most important service.

The ground on which a Grand Jury has indicted two prominent officials of the New York Central Railroad for the Woodlawn wreck is substantially that these men were criminally careless in relying on the judgment of engine-runners to estimate the safe speed of the new electric trains. In the opinion of the jury, the accident was caused by excessive speed on the curve, and the train ran at excessive speed because the engine runner had no proper means of judging how fast his train was going. The jury accepts the idea that an experienced runner of a steam locomotive can tell whether or not his train is exceeding a safe speed; but believes that such experience is not enough to enable such a man to judge how fast an electric locomotive is running.

Now that the question is raised, may it not be well to go a step farther and inquire how many experienced runners of steam locomotives really are able to accurately judge the speed of trains? We venture the opinion that very few can tell at speeds above 45 miles per hour what speed they are actually making with anything like accuracy. It may be claimed that even if the engine runner cannot estimate the speed in miles per hour, he can tell whether he is running at an unsafe speed or not; but this we should consider even more doubtful. To draw the line where speed ceases to be safe and becomes unsafe would be a difficult task for a man of much higher technical rank than an engine runner.

In the investigation of this disaster before the Coroner's Jury, much surprise was expressed by the investigators and by the newspaper press that there were no speed indicators in the cab so that the engineer might know how fast he was running and not have to estimate so important a matter. We raise the question whether there is not good reason for such surprise? Is it not time the engineer of a fast train carrying hundreds of passengers was given an instrument by which he may know what speed his machine is making at any time without having to guess at it? Locomotive speed indicators have been made and put on the market which were, we believe, accurate and inexpensive; but they have never come into general use simply because railway officers considered them a useless refinement. We raise the question whether this ultra-conservative policy ought not to have an end.

Excessive speed spells danger as surely as excessive boiler pressure, but while the engineer has a gage before him to show the boiler pressure, he has to guess at the speed he is making. What is the result? It is simply that the speed of the trains on your road, Mr. General Manager or Mr. Superintendent, varies very considerably with the personal equation—or, to put it plainly, amount of dare-devil—in the man at the throttle. Engine runners are more or less accustomed to take chances; if they were not they would follow another occupation. Their only limitation as to speed is the schedule, and when a train is behind time, and the "plug-puller" wants to make it up, it is he and not the President or the General Manager or the Chief Engineer or any other official that decides what speed that train is going to make on the easy stretches of the open road.

We believe this condition is simply a survival of the day of primitive things. We believe it is time every locomotive in passenger service was equipped with a speed recorder showing to the engineer at any moment what speed he is making. If we mistake not, speed recorders are in extensive use on the railways of Continental Europe, and our American roads may well copy foreign practice in this matter.

Because the Keystone express on the Pennsylvania R. R. was running at only 30 miles an hour when it struck a displaced rail on March 27 near Wilmerding, Pa., the resulting derailment caused no deaths or injuries and little damage to the rolling stock. The rail had been tampered with by train wreckers, all the spikes removed, the rail joint unbolted and connection made so as to prevent interruption of the rail circuit. Such work is fiendish and none the less fiendish because it resulted in little harm instead of causing the death or injury of a trainload of passengers, as it was intended to do.

Because fiends exist who will perform such dastardly acts, however, is another reason why excessive speeds on railway service are unsafe and unwise.

Apropos of the current discussion concerning derailments on curves, we note a wreck recorded in the quarterly Accident Bulletin of the Interstate Commerce Commission, in which a train ran over a 10° curve at a speed of 45 miles an hour. The engine, tender and first two cars went down an embankment and into a lake. Seven persons were killed and forty injured. The centrifugal force per ton on a 10° curve at 45 miles per hour is about 470 lbs. The superelevation was 5½ ins., which would give a centripetal effect of 187 lbs. per ton, and leave a net centrifugal effect of 283 lbs. per ton.

In our last week's issue appeared an editorial discussion on the danger of open switches and the need of better protection for trains running against facing switches. On the day this editorial was published, a Southern Pacific express train of 14 cars ran into the yards at Colton, Cal., at a speed of 50 miles an hour and was wrecked at an open switch. The casualties amounted to 22 persons killed and over 100 injured. Fire in the wreck was averted by the heroism of Victor Clapp, the fireman on the locomotive. He saw the open switch ahead, and instead of jumping to save his own life he rushed to the tender and shut off the valve from the oil tank to the firebox. He was crushed under the tender when the crash came.

In the Coroner's investigation of this disaster, the following interesting testimony was given by the yard foreman, as quoted in the press dispatches:

> Switch Foreman Alvord testified that when he came to work in the morning he saw that the first section of the Sunset Express, known as No. 9, was chalked up on the board as eight hours late. When he returned from his lunch he inspected the board and found it silent as to No. 9, and as the eight hours' limit had expired he concluded the overland had gone through during his absence. This error was not discovered by him until he heard his engineer whistling a frantic signal at the switch to the overland to stop. The overland was then half across the Santa Ana bridge. It was impossible to get back and close the switch because the fated train had reached it.

Certainly, if such happy-go-lucky methods of closing switches in advance of fast trains are in force on any road, then the only safety in train movement is to adopt the rule of approaching all switches with the train under control until the engineer can identify the position of the switch. In fact, it seems surprising that the train should have entered the Colton yard at such a high speed, anyway. It may be necessary on Eastern roads, where stations are close together, to maintain high speed for through trains past unimportant stations, but in the sparsely populated West the delay involved in slacking speed before reaching the yard limits at important points would amount to a mere trifle in delaying train movement.

It is a fact that a large proportion of train accidents occur not on the open road but in station yards; and one of the chief advantages of a proper yard interlocking system is the assurance it gives that proper danger signals

are displayed to stop an approaching train whenever main line switches are opened or the main tract is occupied for switching purposes.

The energy with which railway companies are now undertaking the proper signaling of their lines is indicated by the fact that one of the principal signal manufacturing companies announces the undertaking of extensions which will double the capacity of its works. In 1906 its business increased 70% over 1905, and the indications are that the output this year will approximate $10,000,000 in value. Up-to-date signal equipment is expensive, but railway managers are coming to recognize that it is not a luxury, but an absolute necessity, the purchase of which has in many notable cases been far too long deferred.

The reckless use of lumber in this country and the reckless destruction of the forest resources have been many times referred to, but as yet there has been little general improvement in the conditions, although increasing prices due to a decreasing supply indicate that the users of lumber in various forms will at no distant date be compelled to adapt themselves to a change in conditions. In a paper recently presented before the Western Society of Engineers by Mr. R. S. Kellogg, of the U. S. Forest Service, the value of the annual output of forest products was estimated at $1,000,000,000 (at point of production), while the amount of wood cut to supply these products was about 20,000,000,000 cu. ft. The amount of lumber cut annually increased 94% in the 20 years from 1880 to 1900, while the increase in population for the same period was 52%. As to the increase in price, it was shown that in 1904 the prices of hemlock, southern yellow pine, cypress and white pine were $11.50, $16.50, $30.50 and $47, respectively, per 1,000 ft. B. M.; at the end of 1905, however, the prices were $22.25, $29.50, $42.50 and $91. The increase was about 100%, except for cypress, and the price for that increased considerably during 1906.

Mr. Kellogg's paper, a condensation of which is printed elsewhere in this issue, takes up the economic developments in the general production of lumber which the past waste and present scarcity have necessitated. It does not refer particularly to railway work, but it may be said that in regard to railway ties the situation has already become serious and has led to an extensive development of tie-preserving plants within the past few years, largely for the purpose of making inferior timbers economically available for railway use. The use of timber trestle bridges has been diminishing materially in recent years. Steel freight cars have already largely replaced wooden cars, and their use is rapidly extending; the majority are built entirely of steel, but there are also large numbers of cars with steel frames and wooden bodies. The use of all-steel cars and cars with steel underframes in regular passenger service and suburban service, and on electric street and interurban railways, is also beginning to be a feature in rolling stock equipment.

The committee of Pennsylvania Railroad officials which has been investigating the possibilities in the use of motor cars is undoubtedly correct in emphasizing the saving in train crews as the chief advantage to be gained by the use of such cars. The saving in fuel in most localities by such cars compared with light locomotives, would not be great enough to cut any very considerable figure; but it would be a very great advantage to move a passenger coach with a crew of two men instead of a crew of at least four, which is about the minimum with which any locomotive-hauled train, no matter how light the traffic, is ever handled.

For suburban service, however, there seems to be little benefit in the use of such cars, as the rolling stock equipment is fixed by the demands of the rush hours and may as well be used for whatever train movement is necessary during other hours as to let it lie idle and use something else. The real field for the motor car, and probably the only field where it can score a success is on branch lines with small passenger traffic.

DOUBLE-TRACKING AND YARD IMPROVEMENTS TO FACILITATE FREIGHT TRAFFIC ON RAILWAYS.

The important position which double-track facilities and yards and terminals represent in relation to the efficient handling and prompt movement of railway freight traffic has only within very recent years been given its due consideration, but is now being forced upon the attention of railway companies by the recent unprecedented congestion of traffic in all parts of the country. In our issue of Jan. 24 we undertook to expose the fallacy of the argument put forth by Mr. James J. Hill, of the Great Northern Ry., to the effect that a vast additional mileage of extensions of the railway system of the country is necessary to relieve this congestion. As a matter of fact, it is only the main lines of the railway system that experience this congestion, so that the construction of new lines and branches would rather aggravate than relieve the situation by bringing additional traffic to the main lines, while new main lines or through routes would simply introduce new and undesirable competitive conditions. We pointed out that in most sections of the country additions to railway capital can far better be devoted to double-tracking existing lines and enlarging yards and terminals than to building new competing through lines. The subject is of sufficient importance to warrant a more extended review of the advantages of ample trackage and yard facilities on busy main lines of railway in facilitating the forward movement of freight to its destination. This subject is, of course, quite distinct from that of the proper distribution of cars to meet the requirements of shippers, as to which we may have something to say in a later article.

Taking up first the matter of trackage, it is of course evident that one double-track line has a much greater capacity than two independent single-track lines, both of the latter being subject to the delays and inconveniences which are removed or reduced in very large degree by double tracking. The relation of double track to traffic capacity and efficiency was discussed at some length in our issue of Sept. 14, 1905, and it was shown that on single-track lines of heavy traffic the trains may spend a considerable proportion of their time on side tracks, waiting for opposing trains, which latter may often be late and so increase the delay. With a double-track line these delays would be eliminated, and the only road delays would be those due to taking the side-track in order to allow passenger or superior freight trains to pass in the same direction. Thus a smaller number of engines might be able to handle a much greater amount of traffic, and with greater promptness and economy. In one particular case of a single-track line, an engine which spent 464 hours on the road in a given month had 128 hours of delay due to waiting for trains to pass, and its average speed while in service was only 5.7 miles an hour. It is of course evident that the operation of heavy traffic is much simpler and safer on double track than on single track, while the efficiency and safety in either case may be greatly increased by the general use of the block system.

The latest report of the Interstate Commerce Commission gives the total railway system of the country in 1905 as 217,000 miles, with 17,000 miles (or 8%) of double track. Allowing for the active work in railway construction and improvement during the past two years, it is evident that not one-tenth of the total mileage is yet double-tracked. It must of course be remembered that it is only the lines carrying heavy traffic that require double tracking, but even making this allowance it may be reasonably estimated that the proportion should be 20 to 25% (say 44,000 to 55,000 miles), so that there is a decided deficiency in the proportion of double track, even on lines of this particular class. This means that many roads or divisions are handling a "double-track traffic" on a single-track line. From the latest annual reports of 22 railways, with an aggregate mileage of 78,348 miles, we find that only 6,460 miles (or about 8%) have double track; the three and four-track sections of line aggregate only 309 miles. These figures are tabulated below. The total mileage given includes, of course, main lines and branches, so that, as noted above, the relation of the length of double track to the length of actual main line is not apparent:

DOUBLE TRACK ON AMERICAN RAILWAYS.

Railways.	Length, miles.		Double track, miles.	Third and other main track, miles.
Union Pacific (1).....	3,128	(incl. 1,860 of branches)	163	..
U. Pac., Ore. Sh. Line and O. Ry. & Nav..	5,664		168	..
A., T. & S. F.....	8,434		300	6
Denver & Rio Grande.	1,620	(st. gage)	62	..
Nor. Pacific	6,223		124	..
Great Northern.....	6,248		88	22
Chicago & N'western.	7,352		862	32
Chi., Mil. & St. Paul..	7,043		448	10
Chi., Bur. & Quincy...	8,608		525	..
Ill. Central	4,460		677	72
Chi. & E. Ill.....	817	(673 main)	154	17
Chicago & Alton (2) ..	947		128	..
Southern	6,885		155	..
Norfolk & Western....	1,861		186	..
Chesapeake & Ohio (3).	1,827		334	..
Wabash	2,517		135	..
Lehigh Valley	1,445		577	41
Del., Lack. & Western.	957		512	..
Phila. & Reading.....	999		486	54
Hocking Valley	347	(279 main)	47	..
N. Y., Ont. & West...	272	(main)	98	..
N.Y., N. H. & Hartford	628		253	55
Total.....78,348			6,461	309

(1) Of the 163 miles of double-track on the Union Pacific Ry., 62½ miles were built in 1905-06; in June, 1906, there were 88 miles more under construction at various points. It is to be noted that the road has automatic electric block signals along the entire length of its main line from Council Bluffs, Iowa, to Ogden, Utah, 1,000 miles.

(2) In three cases the parallel single-track lines of the Chicago & Alton Ry. and another railway are operated jointly by the two lines as double-track sections; these three sections aggregate 117 miles in length.

(3) Of the 334 miles of double-track on the Chesapeake & Ohio Ry., 37 miles were built in 1905-06; in June, 1906, there were 111 miles additional authorized and under construction. Except for about 130 miles, there is double-track along the main line from Newport News, Va., to Cincinnati, Ohio, a distance of 666 miles.

In the investigation of the question of the extra facilities of double-track over single-track lines, our attention has been called to a statement prepared in November, 1906, by Mr. B. A. Worthington, First Vice-President and General Manager of the Wheeling & Lake Erie Ry., in regard to the improvement in traffic capacity that would be effected by double-tracking that road. The statement was based on a time-card chart showing the regular and extra freight trains operated on the main line of the railway on Sept. 2, 1906, and the salient points of the figures shown by this chart may be summarized as follows:

	Eastbound.	Westbound.	Total.
All freight trains, including helpers and short runs....	85	75	150
Through freight trains:			
Total number	34	30	64
Total cars	..	..	2,612
Av. cars per train.....	..	..	42.30
Total mileage 2,550.10		2,101.10	4,351.20
Total hours on road.....	257.08	261.28	518.36
Total hours a day.....	105.27	115.41	221.08
Av. speed between terminals	8.70	8.00	8.40
Av. speed while running..	14.80	14.40	14.60
Meeting and passing points; total number...			296
Av. per hour.....			12.3
Max. per hour.....			21.0
Min. per hour.....			6.0

The statement upon the conditions indicated by the above, and upon the improved conditions which would result from the double-tracking of the line, is given below, from a copy furnished us by Mr. Worthington:

Daily records for a period of two years on different divisions of the Southern Pacific Co.'s lines, showed that the time actually consumed in stops on freight runs having physical characteristics similar to the Wabash Ry. lines east of Toledo, varied from 30 seconds to one minute per mile run on single-track line, according to the density of traffic. The chart for the Wheeling & Lake Erie Ry. shows that the time consumed for delays on through freight runs averaged slightly over three minutes per mile run; this is incident wholly to the congested condition of the line, as it is more than three times what this delay should be under normal conditions.

While we have no data available showing the time actually consumed by freight trains on a double-track line (which, of course, would be affected by the number of fast passenger trains which freight trains running in the same direction would be required to clear) it is probably reasonable to assume that the delay on a double-track line under average normal conditions would not be greater than on single-track line under similar conditions; namely, one minute per mile run. Assuming

that the line between Pittsburg Junction and Huron Junction was double-track, the time allowance for stops on the 181 miles would mean two hours and four minutes, which would seem to be ample.

On this basis, the delay of 221 hours, 8 minutes, actually consumed, would become 72 hours, 30 minutes, a saving of 148 hours, 37 minutes, and as this saving of time could readily be converted from "delayed" to "moving" time, the average speed of through freight trains "between terminals" would become 11.8 miles per hour instead of 8.4 miles per hour under present conditions. The actual running time of trains need be no faster than at present. Furthermore, the overtime payments now average about $12,000 per month in train service, and very likely would also be reduced in the same proportion as the reduction in delayed time, or a saving of about $8,000 per month on this item.

The increase in the speed of through-freight trains between terminals would mean a gain of 1,753 train-miles for the day in question. The average earnings per freight train-mile for September were $3.21. Applying this to the increased train mileage (1,753 train-miles) the earnings on this particular day would be increased $5,628. As this is only an average day's business, the annual gross earnings would be approximately increased $1,500,000; allowing 60% for operating expenses, the net money would be $600,000, and this amount, capitalized at 5%, would be equivalent to earning interest on $12,000,000. At the same time the road would be getting the benefit of a double-track line, which would enable it to increase its volume of traffic fully three times.

It will be seen that if with a double-track line we could get an average movement of 11.8 miles per hour between terminals (instead of 8.4 miles per hour), which all practical railway men know is not an unreasonable expectation, this result alone would increase the capacity of our present car and locomotive equipment over 40%.

Close inspection of the chart shows considerable delay to westbound trains at Bolivar and Navarre, and to eastbound trains at Sherwood. This is incident to inadequate yard facilities at Columbia, the principal intermediate freight terminal, necessitating holding out trains until this yard can be relieved. When the new 2,000-car yard at Brewster, now in process of construction on the 22-mile cut-off line from Orrville to Bolivar, is completed, the delay at Columbia Yard will be entirely eliminated.

But while the detentions due to operating conditions on the open line are serious enough to warrant the undertaking of very thorough means to eliminate them, the worst delays to the continuous forward movement of freight are those which occur in the switching yards; and through cars must pass through a number of such yards in traveling to destination. At the smaller yards, inefficient construction or operation may lead to an almost universal detention of cars much greater than what should properly be required for the sorting of incoming trains and the making up of outgoing trains. In many of the larger yards, extensive improvements have been made in order to increase their capacity, and to facilitate the general movement of cars, but a vast amount of work of this kind needs to be carried out in order to relieve the present pressure and congestion and to provide for a more prompt and economical handling of freight transportation as a whole. In many large cities, the detentions are aggravated by the necessity of transferring cars from one road to another. Thus at Chicago, which is a terminal point for every road entering it, an incoming train on any one road may have some local cars for Chicago and some through cars to be forwarded over each of four or five other roads. The train has first to be handled in the yard of its own road, the local cars separated from the others, and the through cars separated for their respective forwarding roads, to whose yards they are hauled by switch or transfer engines. In the latter yards they have again to be sorted and switched in making up the outgoing trains. As the cars may be separated at the arrival yard just too late for an outgoing cut of transfer cars, or arrive in the yards of the forwarding road just too late to be made up into an outgoing train for their particular destination, the aggregate detention from the time the cars arrive in one train to the time they leave on another train may run into days.

This series of movements and delays was discussed at some length in our issue of Jan. 2, 1902, in connection with the establishment of the Chicago clearing yards. The purpose of this plant was to remove all through cars from the city yards of individual roads. Incoming freight trains would run direct to the clearing yard, the local cars delivered to the several city yards and the through cars made up in outgoing trains ready for the road engines of the several roads. The plan could only be worked to advantage with the cooperation of a number of the railways, but unfortunately this has not been obtained by the company owning the clearing yards, and the extensive and well-planned yard plant has never yet been used.

It has been estimated by officers in the car service departments that freight cars are in movement on the road only about six hours per day (or less) and that the average speed is but four miles an hour, making the daily mileage only 24 miles. Other estimates put it at only 16 miles traveled per day. Mr. W. E. Beecham, of the Chicago, Milwaukee & St. Paul Ry., remarked at a recent meeting of car service officers that while some speakers had stated that freight moved with "reasonable dispatch" on their roads, he desired to be put on record as saying that "freight does not move with proper dispatch on any railway." At a meeting of the American Railway Association in October, 1906, a report of the car-service committee was presented giving returns from 130 railways, with 1,497,274 freight cars in service and operating 177,415 miles of road. The average mileage per freight car per day was 23.55 miles, ranging from a minimum of three miles to a maximum of 43 miles per day. Of the 109 railways specifically reporting the daily mileage, the returns may be summarized as follows: less than 10 miles per day, 26 roads; 10 to 20 miles, 35 roads; 20 to 30 miles, 35 roads; 30 to 40 miles, 13 roads. Thus on about 70% of the roads the average movement is only 10 to 30 miles per car per day.

The necessity of prompt movement of cars through freight yards for economic and competitive reasons was referred to by Mr. H. M. North, in a paper on "The Design of Railway Freight Terminals," published in our issue of Feb. 7, 1907.* He stated that the time of passing ordinary freight through a yard, from the time of arrival to that of departure, should not exceed four hours, while expedited freight can be put through in one hour; freight that must be transferred, rearranged, shifted or otherwise handled should not, he says, be detained more than 12 hours. We have made a somewhat extended inquiry as to the matter of detentions of cars in yards, not including the cars which have reached destination or those which go through in fast freights or solid trains without being switched. It has been found difficult, however, to get much definite information, officials being unwilling or else frankly owning their inability to give figures. The few figures we have succeeded in obtaining may be summarized as follows:

DETENTIONS OF THROUGH CARS AT YARDS.

	Number of cars daily.	Per cent. of through cars.	Detention in yard. Min. hours.	Max. hours.	Av. hours.
Terminal R. R. Assoc., St. Louis	6,200	78	3	23	..
Wiggins Ferry Co. St. Louis	2,000	85	2	23	..
Ill. Central R. R., Chicago	1,800 rec. 1,800 for.	50	..	..	48
Scranton, Pa.	..	80	..	..	9½
Pennsylvania R. R. (classification yards)	..	..	..	..	5½
Pennsylvania R. R. (yds. for making up trains and also delivering freight to customers)	..	..	..	..	9½
Southern Ry.	..	..	..	..	13 to 20
Various division yds.	..	..	..	..	6 to 12

In regard to the figures for Chicago and St. Louis, it must be remembered that at both these points cars have to be transferred from one line to another and handled in the yards of both lines concerned. At the other points mentioned, the cars simply pass through the division yard.

In addition to the delays to cars passing through the division yards, another matter to be considered is the delay to local or destination cars; that is, the cars which on arrival at the yard have not to be forwarded but are to be unloaded in the yard or sent to some local industry for unloading. It appears that in some cases, a car may wait for days in a yard before it is moved to the industry's track and then again left empty on that track for an equal time before being brought back into the yard for movement in train service. We learn that at Chicago the average delay to cars from the time they reach their stations to the date of their being reconsigned or unloaded is about 2.33 days; this includes both railway and consignee detention, but apparently not the return of the car. At St. Louis, however, the minimum time for local cars is 48 hours, with a maximum of ten days and an average of six days; this represents the total time elapsed after the car comes in off the road until it is unloaded at the industry tracks and returned to the trunk line for reforwarding. There is no doubt that a great improvement might be made at once by a revision of the connections from the yards to industries, by a strict supervision of the local switching and car movements, and also by a strict observance of the per-diem and demurrage penalty rules. This is not the only remedy, however. In very many cases the trouble lies directly with the industrial tracks; that is, the tracks not owned or controlled by the railway. These tracks are apt to be poorly arranged and built, of limited capacity, and with ill-arranged connections to the railway company's tracks or yard system. In fact, in a recent letter to the Interstate Commerce Commission, Mr. Russell Harding, formerly General Manager of the Missouri Pacific Ry., estimated that 75% of the car shortage troubles were due to this cause alone; this estimate, however, seems to be too high.

We are informed by Mr. A. G. Thomason, Secretary of the National Association of Car Service Managers, that the records of the various local associations represented in the national organization show that for 5,690,934 local or destination cars handled during the three months ending Sept. 30, 1906, the average detention by the railways was 0.38-day per car. This indicates the time consumed by the railways in placing cars at designated points for unloading, after their arrival at destination. For the same number of cars, the detention by shippers and consignees in loading, unloading and furnishing forwarding orders, averaged 1.45 days per car. Thus the total detention per car averaged 1.83 days. For the year 1905, the records covering 26,196,950 cars show an average detention of 1.81 days per car, of which 0.41-day was by the railways and 1.40 days by the public. In all computations of detention by the car-service associations, however, Sundays and legal holidays are omitted. In one particular large yard, which is generally congested, the railway holds consignments of grain, hay and similar commodities for diversion orders from the shipper or consignee. Including the free time provided for giving notice of arrival at this yard, the time allowed for diversion is about 2 days 14 hours per car, exclusive of Sundays and legal holidays. When a car is ordered out of the yard by the shipper or consignee there is usually considerable delay, because the car may be in the middle of a large yard filled with cars awaiting orders. There are no systematic records to show what is the detention to such cars after the forwarding orders are received.

In a paper read at the St. Louis meeting of the Association of Transportation and Car Accounting Officers in 1905, Mr. T. S. Bell, of the Pennsylvania R. R., made the following statement:

> We are endeavoring to formulate some methods by which car movement can be given closer supervision, and establish such records and methods that will give our people the necessary information to keep in touch as to yard delays, train and car movement, terminal delays and delays at sidings and point of shipments where freight originates. It is also necessary to keep a close supervision over the empty cars in order to keep in touch with the flow of empties so that they con be placed promptly for outbound business. We have been keeping certain records during the past year, and find that our greatest trouble is to get cars through yards and released at terminal points. These are the big problems which we are endeavoring to solve first. The movement on the road is not always what it ought to be, but we are endeavoring, as above stated, to apply such means and methods at yards and at terminals which will improve the service. After we decide ex-

*This is published in full in the Journal of the Western Society of Engineers for February, 1907.

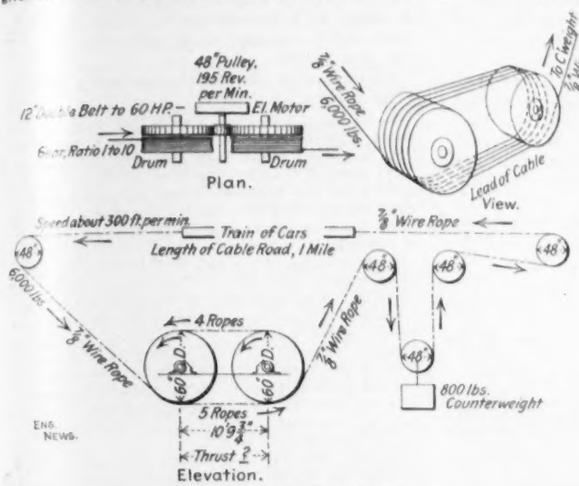
velop as much resistance as would be expected of a similarly reinforced panel.

Very respectfully, W. J. Douglas,
Engineer of Bridges, D. C.

Washington, D. C., March 29, 1907.

A Rope-Drive Problem.

Sir: A problem has come before me which seems to be rather difficult to solve, and I therefore ask the aid of your readers in solving it. The accompanying sketch gives all necessary information. As you see, we have a



A ROPE-DRIVE PROBLEM.

cable drive with two drums, each 60 ins. in diameter. The incoming line, which has a load of 6,000 lbs., coming in on one drum and after making 5 laps about both drums, leaves from the other, going over a take-up sheave having a weight attached of 800 lbs., to a leading sheave and out. What thrust is there between bearings of drums?

Hoping you will favor me with an early reply, I am,

Yours very truly, O. Grimm.

7315 Kimbark Ave., Chicago, Ill., Feb. 28, 1907.

Examination for Chief of Bureau of Water, Philadelphia.

Sir: Referring again to the subject of examination for Chief of the Bureau of Water in Philadelphia [see Eng. News, p. 330, March 21, 1907—Ed.], while it is not literally the fact that the 400 points of the oral examination were wholly on the subject of administrative experience and ability, they practically applied to those elements. Each candidate was carefully examined orally on what he had done, and his knowledge of the technical parts of that experience, especially in the matters of civil and mechanical engineering, was thoroughly tested, so that although a portion of the oral examination was credited to those technical subjects, it was in connection with his experience and administrative ability. Practically, I should say that about one-half the weight of the examination was determined by technical knowledge and the other half by administrative experience and ability, partly as shown by a technical knowledge of the things in which he had had such experience.

The reason that the markings were low was from the fact that the examination was severe and the marking rigid. Shortcomings in one feature received no allowance on account of excellence in others. There were some gentlemen of high scientific attainments who failed in our judgment on administrative qualifications, and there were some who doubtless were excellent administrators who were seriously handicapped by a lack of technical training along the two lines which the examination covered.

The matter of the non-appointment of the one candidate who passed is not within the jurisdiction of the examining board, and, as I see it, has no bearing upon the applicability of Civil Service examinations to such positions, and the Civil Service Commission has nothing to do with the ordinance passed after the examination was held limiting the appointment to residents of Philadelphia. There are points in favor and against such a regulation, but that is another matter.

Very truly yours,
Cassius E. Gillette,
Chief Engineer, Bureau of Filtration.

Philadelphia, Pa., March 26, 1907.

Engineer's Estimates for Partial Payments.

Sir: Your issue of March 14th contains a statement of "A Subscriber" writing from Montana, relative to the practice of certain railroad companies in withholding a substantial part of the yardage removed in any month, over and above the usual percentages agreed to be retained in the terms of the contract, and asking for an expression of other engineers and contractors on the subject.

The custom wherever and whenever followed is on the face of it plainly a flagrant violation of the contract, so lacking in fairness or honesty of purpose that it stands self-condemned. It must be evident to the youngest and least experienced engineer that contractors undertake their work having at their command certain equipment and money or credit, and obligate themselves accordingly; and to deprive them of their money when due is to break down most effectually their credit, and not infrequently embarrass them and prevent the prime object of the letting of the contract, viz., its prompt and efficient completion. If the contractor pulls through notwithstanding these difficulties, and is eventually paid up in full, he has, nevertheless, been subjected to a straight and bare-faced steel to the extent of the interest on his money, while illegally held back, whether the shortage has resulted from the failure of the resident engineer to make a careful and full estimate on classification and yardage each month, or from the self-delegated and assumed authority of some one higher endeavoring to temporarily assist in financing the road. The unwarranted custom is resulting in the necessity of contractors maintaining, even on railroad work, an independent corps of engineers, for the purpose of checking; as they are beginning to find it economical to pay this charge in preference to having an undue amount of capital tied up, unfairly. The custom of short estimates should, for the honor of the engineering profession, to whom it is commonly attributed, be no longer tolerated or excused either in railroad, municipal or other contracted work. The other custom of denying to the contractors access to all data relating to such monthly and final estimates is equally indefensible.

Yours truly, V. P. Strange.

Salt Lake City, Utah, March 22, 1907.

Tables for Roadmasters.

Sir: Please note the accompanying tables which I prepared some time ago for the use of roadmasters. The table of chord offsets (Table I.) seems to be appreciated by them in roughly going over propositions for tracks, particularly at outlying points where it seems hardly worth while to send an engineer to make a survey, when the parties to be served by the track expect to do the grading themselves. A careful man can secure very fair results with this table which he would not ordinarily be able to do. Roadmasters also I find have been having difficulty in cutting their rails on curves in many places, it being necessary for foremen to lay the track around to the end of the curve, keeping their joints about where he thinks they should be and cutting the rail to fit when he gets to the end of the curve. With a large extra gang and many curves in the track, it is of great advantage if the roadmaster can give to the extra gang foreman who is relaying the steel the exact cuts on all the curves, and seems to facilitate the work considerably.

You perhaps have published similar tables to these, but I have not seen any in recent years. If you think these tables worth it, I would be glad to have you print them for the benefit they may be to maintenance engineers who would no doubt have a copy made for their roadmasters where they would hardly go to the trouble of making them up in the first place.

Yours truly, W. W. Gaffin,
Division Engineer.

Chicago & Northwestern Ry. Co., North Fond du Lac, Wis., March 7, 1907.

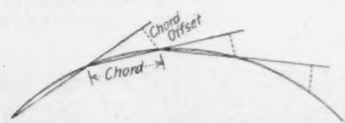


TABLE I.—TABLE OF CHORD OFFSETS FOR ROADMASTERS.

Degree.	Offset for 50 ft. chord.	Offset for 100 ft. chord.	Degree.	Offset for 50 ft. chord.	Offset for 100 ft. chord.
0° 30′	0.2	0.9	6° 0′	2.6	10.5
1° 0′	0.4	1.7	7° 0′	3.0	12.2
1° 30′	0.6	2.6	8° 0′	3.5	13.9
2° 0′	0.9	3.5	9° 0′	3.9	15.6
2° 30′	1.1	4.4	10° 0′	4.4	17.3
3° 0′	1.3	5.2	12° 0	5.2	20.8
3° 30′	1.5	6.1	14° 0′	6.1	24.2
4° 0′	1.7	7.0	16° 0′	7.0	...
4° 30	2.0	7.8	18° 0	7.8	...
5° 0′	2.2	8.7	20° 0′	8.7	...
5° 30	2.4	9.6			

TABLE II.—SHOWING DIFFERENCE IN LENGTH OF OUTSIDE AND INSIDE RAILS ON CURVES FOR 100-FT. LENGTHS.

Degree of curve.	Difference for 100 ft. in ins.	Degree of curve.	Difference for 100 ft. in ins.
0° 15′	.2465	4° 30′	4.4374
0° 30′	.4930	5° 0′	4.9305
0° 45′	.7396	5° 30′	5.4235
1° 0′	.9861	6° 0′	5.9166
1° 30′	1.4791	7° 0′	6.9027
2° 0′	1.9722	8° 0′	7.8888
2° 30′	2.4652	9° 0′	8.8749
3° 0′	2.9583	10° 0′	9.8611
3° 30′	3.4513	11° 0′	10.8471
4° 0′	3.9444	12° 0′	11.8333

Example: 3° 30′ curve 615 ft. long. 3.4513 × 6.15 = 21.25 in. = 21¼ ins.

[These figures have been published in the same or similar form in text-books and also in the technical press; but for the immediate benefit of roadmasters who may not have them at hand we reproduce them herewith. Through an inadvertence the table for "Transverse Contours for Roadway Pavements" was inserted in this letter as published last week. The letter is therefore reproduced in its correct form herewith.—Ed.]

Diagrams for the Design and Analysis of Reinforced-Concrete Beams.

Sir: I am sending you two diagrams which have proven useful in the design of concrete steel beams. They are based upon the theory set forth upon pp. 294-300 of Taylor & Thompson's "Concrete, Plain and Reinforced,"

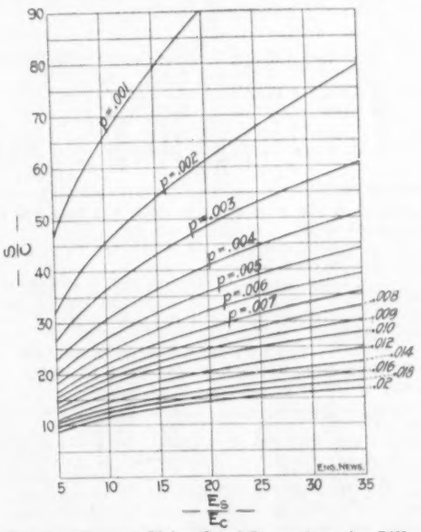


Fig. 1. Diagram Giving Steel Percentage for Different Values of $\frac{E_s}{E_c}$ and $\frac{S}{C}$.

Formula, $$p = \frac{1}{2\frac{S}{C}\left(1 + \frac{S}{C}\frac{E_c}{E_s}\right)}$$

which, as most of your readers doubtless know, is as follows:

(1) A section plane before bending remains so after bending.

(2) Tension is borne entirely by the steel.

(3) Initial strains are absent in the steel and concrete.

(4) Adhesion between steel and concrete is perfect.

(5) The modulus of elasticity of concrete is constant within the usual limits of stress.

The notation is—

S = stress in steel when beam is fully loaded, in lbs. per sq. in.

C = stress in concrete when beam is fully loaded, in lbs. per sq. in.

E_s = modulus of elasticity for steel.

E_c = modulus of elasticity for concrete.

p = ratio of steel to concrete above center of steel.

k = a constant.

K = a constant.

To illustrate their application, assume we desire to figure a job using a concrete whose E_c, either from test or comparison with tests of similar concrete, is believed to be 2,000,000 lbs. per sq. in., and a steel whose E_s = 30,000,000 lbs. per sq. in., and that S = 14,000 and C = 500 lbs. per sq. in.

Then $$\frac{E_s}{E_c} = \frac{30{,}000{,}000}{2{,}000{,}000} = 15.$$

$$\frac{S}{C} = \frac{14{,}000}{500} = 28.$$

actly what we are going to do as to keeping records and establishing better supervision in yards and at terminals, we then expect to take up and establish an audit (analysis of delays) at all stations and sidings and coal tipples, etc., so far as we find it necessary to carry out the general plan of getting supervision of every car on the road.

At the same meeting it was stated that on the Southern Ry. steps had been taken to reduce the yard delays. By taking the conductors' reports of outgoing trains, and finding the time at which each car had arrived at the yard (shown by the reports of conductors of the inbound trains), it was possible to find the delay to each car. The average was found to be 18 hours, which was reduced to 13 hours, although even that was considered far too much. On the main line from Washington, D. C., to Greenville, Miss., 1,107 miles, there are seven relay points, and if a car of freight should meet with the average delay at each of these points it would mean 91 hours (practically four days) delay, or 13 hours rest after every 158 miles run. Much of this delay is due to holding the trains to make up the full tonnage rating, but this may be overdone, as what is saved in transportation expenses is more than lost by having the car idle and out of service. In this connection we quote remarks made by Mr. J. N. Searle, of the Southern Ry., at the meeting above noted.

If we were to eliminate our through trains that go through a terminal, and take into consideration only the delays to slow freight, our delays would be something like 20 to 24 hours. That seems very unreasonable, but it is true. We have bettered it, and are going to make a much greater improvement. I have some blanks which we are using in the big yards to check the delays; these show what the delay is chargeable to: whether waiting for engines, waiting for the trains to be made up, or waiting for other trains so that the freight train cannot get out on the road. We have told our superintendents that it is all well and good for each of them at times to hold a train for tonnage, but if all of them were to hold the same train or the same bunch of cars, what would be the result? Now, none of our trains wait at terminal points. Where there is a great lot of traffic it cannot always be done, but we have so arranged it that we take care of each freight train as it comes in. We have company coal or something to fill in with that train to give it its tonnage.

In the design of yards for either construction or improvement, two main points have to be considered: (1) the arrangement of the terminal as a whole, with the proper relative locations of the several individual yards and other facilities; (2) the arrangement or design of each of these several yards. Besides the provision of ample space, the arrangement of the yard and its various accessories has very much to do with the speed and facility of operation. The mere increase in number and length of track may actually impair rather than improve the working conditions, by multiplying the difficulties incident to a defective original design. In this connection we quote from Tratman's "Railway Track and Track Work":

The main idea in enlarging a yard is usually to provide more tracks for cars to stand on, the too general idea of a yard being that the principal consideration is to have plenty of tracks upon which to store cars, while, as a matter of fact, a yard is intended for sorting and distributing cars, rather than for storing them. The quicker the car is passed through the yard from the time of its arrival off the road until it is delivered at its unloading track, or sent out again to continue its journey, the greater will be operating efficiency and economy of the yard service. This economy and efficiency will also extend through the whole freight service, for if the cars are handled promptly there will be less delay in providing empty cars as called for, and consequently the capacity of the equipment will be increased, thus avoiding the necessity of purchasing new cars. If a yard is too large, or its track capacity is too great, there is likely to be a lack of promptness in clearing it and getting the cars moving over the road. On the other hand, if it is too small, blockades will almost certainly occur, interfering with the movement of freight trains on the road, while the hurried and complicated switching in an overcrowded yard will tend to greatly increase the damage to rolling stock.

Methods for facilitating the movement of cars through yards have been under consideration for some time by the committee on conducting transportation of the Association of Transportation and Car Accounting Officers, but as yet its recommendations have related principally to the adoption of a proper system of auditing the cars, by the use of forms of report which will show for each car the time at which it arrived and departed, and the time it spent in the yards. A very similar system is necessary to control the handling of cars by station agents. A much more radical, and apparently quite practicable, step was suggested by Mr. J. M. Daly, of the Illinois Central Ry., in the discussion of this committee's report at the New Orleans meeting in November, 1906. This was, in brief, that solid trains should be run between important points; thus each train would be made up entirely of cars for its own destination, instead of having cars for numerous destinations. With the proper arrangement of cars at the initial point by such a system, the switching at intermediate points would be greatly reduced, with consequent reduction in delays to cars and in cost of yard work. We give the substance of Mr. Daly's suggestion as follows:

Freight moving eastbound from Chicago is now made up in trains with some cars for Buffalo, some for Cleveland, some for Boston, some for Philadelphia, and some for New York. My idea is that the time is coming when stations like Chicago will build solid trains of freight for New York, and similar trains for Boston and Philadelphia. On the Cleveland business it would pay Chicago to hold the loads two days in order to make up one solid train of dead freight to that point. The benefit would be in saving six to twelve hours at Elkhart, at Toledo, at Cleveland or Erie, and again at Buffalo (24 to 48 hours in all). Under our present method we are breaking up every train at nearly every terminal point, because there are some cars in it that must come out, and other cars in the yard that must be added to it. Freight held 48 hours to complete a full train would still make better time after it is made up in a solid train than we make to-day. The only breaking at the important terminal points would be on two or three mixed trains, containing miscellaneous loads, where the business is not enough in two or three days to justify a solid train.

The difficulties in supplying cars to shippers appear to result from congestions and delays in the handling of traffic and not to any shortage in the supply of cars. Nor does it appear that a deficiency in motive power equipment has very much to do with the delays.

The conclusions to be arrived at from the matter presented above may be briefly presented as follows: (1) It is abundantly evident that improvements on main lines of heavy traffic are needed for the relief and prevention of the congestion of traffic. (2) On lines where freight traffic congestion occurs, attention should be given to the enlargement of track facilities (to expedite the movement of trains) and of yard facilities (to expedite the movement of cars). Improved methods of operating, such as the running of trains solid to their destinations, should also be carefully considered. (3) In the construction and improvement of yards, it is important that the engineering and operating departments should cooperate, in order that the yard, as a machine, may be operated at its highest efficiency.

LETTERS TO THE EDITOR.

Topography With an Abney Clinometer.

Sir: In reply to Mr. F. Lavis in your issue of March 21, 1907, relative to different methods of taking topography: Mr. Lavis condemns the method advocated by me, saying there is "large liability to error in measuring the angle." The angles can easily be measured to the nearest half degree, which would only mean an error of about 0.8-ft. in 100 ft. for the flattest slopes. While this error decreases as the rate of slope increases, why should he notice this small error, while on page 69 of his book on railroad location he says: "The difference between theory and experience here is that theory would require an absolute accurate preliminary and topography, while experience shows that neither is essential if proper methods are adopted in getting the final line on the ground?" I think for speed his method may overrule mine in flat rolling country, as on the "Choctaw," but when he runs into a mountainous country where cliffs, laurel and slopes from 30° to 60° abound, I am afraid his pacing and hand level party would have to "show me."

Yours truly, V. S. Veazey.

Derryhale, W. Va., March 25, 1907.

A Clinometer Graduated to Percentages of Grade.

Sir: I should like to know if there is any firm manufacturing Abney clinometer levels which have, in place of the usual degrees and half degree graduations, a mark by which slopes could be recorded in "per cents" or half "per cents." Such an instrument would have a mark, for example, of ½% at 0° 18′, 1% at 0° 35′, and could be continued to the end of the arc.

With such an instrument the office work on a preliminary taken as described by Mr. V. S. Veazey in Engineering News for March 7, 1907, would be very simple. I have used this method, but have always used an angle of 0° 17′ 30″ as a close approximation to a ¼% slope for small angles. This gives contour points by a very simple mental calculation, and obviates the use of any tables, if measuring is done approximately.

I would like to know if any one ever used an instrument graduated as above.

Yours truly, [illegible] D.

Guantánamo, Cuba, March 18, 1907.

Why Do Contractors Do Slipshod Work?

Sir: I notice in the issue of Engineering News for March 21st, a communication from Mr. A. [illegible]tz in which he asks the very pertinent question, "Why do contractors do slipshod work?"

This desire on the part of some contractors to "skin" the work is a product of the competitive system and can only be prevented by the cost-plus-a-fixed-sum or premium system or another method which I have long had in mind, viz., that the engineers in charge of any important work should be thoroughly informed upon the cost of the work and make accurate estimates of the same; and if the lowest bid should fall too much below this estimate it should be rejected unless it can be satisfactorily shown that the difference is entirely due to superior organization or improved methods of operation.

On any important work, success largely depends upon the honesty of the contractor, and it is useless to depend upon inspectors when work is taken at a figure that is apparently too cheap.

Yours very truly,

John H. Ferguson,

Assistant City Engineer.

Augusta, Ga., March 23, 1907.

The Action of Locomotives on Curved Track.

Sir: In your able discussion on the probable cause of the wreck of the electric train on the New York Central, it seems to me that some important differences between an electric locomotive and a high-speed steam locomotive did not receive much consideration in the matter of their bearing on the cause of the wreck.

The flanging of the four middle drivers (and presumably the sloping of their treads) will tend to give a wedging action against the outer rail, due to the two middle drivers on the inner side of curve having their flanges come in contact with the inner rail. The offset in 13 ft. on a 3° curve is not much, but the slope of the tread of the wheel would make it harder for the one outer driving wheel whose flange is taking the force of the curve to shove the inner drivers back as the locomotive rounds the curve.

The opinion, not yours, that excessive shear on the spikes due to the centrifugal force was the cause of the spreading of rails is not reasonable. If all of the force came on each individual spike the rail would have to undergo a wave motion of exceedingly short wave length. Again, if that force should come on a spike in a tie that was loose, what would hold the tie from moving laterally? A man with a crowbar can move a tie easily. The friction of the tie on the ground and the friction of the rail on the tie are the principal elements in holding the rail and tie in place. The centrifugal force on a 3° curve at 70 mi. per hr. is about one-sixth of the load. The friction on the roadbed and ties ought to be much more than this.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., March 19, 1907.

Reinforced-Concrete Floor Tests.

Sir: Mr. C. A. P. Turner recently requested of me, in your issue of March 7, any full panel tests which I had made carrying out my theory as to the different deflections between exterior and interior concrete slabs in building construction.

I regret to state that I know of no tests which have been made to demonstrate this point, and in my judgment it will require special tests of exterior and interior panels in order that the deflections may be properly compared. It is always a question in figuring a restrained beam, whether or not a beam will act as a restrained beam or purely as an arch, and the writer is of the opinion that the very small deflections which have been noted are due to arch action. Of course there might be arch action in exterior panels under certain conditions of thickness of slab to span, percentage of reinforcement, and method of bonding, in which case the thrust would be taken up by the tie rods. Under such conditions the arch action would probably occur with more or less beam action. The actual stresses, in my judgment, being indeterminate, therefore the flexure would be uncertain, but it seems to me almost self-evident that the interior panels would have less deflection than the exterior. Looking at this interior panel it appears to me that if the reinforcement were omitted in the interior panels with unyielding abutments, you would get almost as high a test as if it had reinforcement, due to the arch action, and I hope some day to be able to make some tests to substantiate my theory. I do not mean to recommend the omission of reinforcement in interior panels, but I think if it were omitted in one panel and that panel tested in the customary manner, it would probably de-

his train. The disaster was a natural result of such carelessness. This matter should not have been left entirely to the discretion of the company.

State regulations should have been in force making such gross carelessness impossible. The safety of human life should not be allowed to be intrusted to the judgment of untrained men.

The grand jury calls attention to these facts, in the hope that the State Board of Railroad Commissioners will make such regulations as will prevent a recurrence of such conditions on any railroad within this state.

A REPORT ON INDEPENDENT MOTOR CARS FOR RAILWAY SERVICE.

A committee of officials of the Pennsylvania R. R. was sent last fall to Europe to investigate the operation of independent motor cars on the railways of England and the Continent.

The committee was composed of Messrs. C. M. Schaeffer, Superintendent of Passenger Transportation; R. N. Durborow, Superintendent of Motive Power, and A. E. Buchanan, Chief Clerk to the General Passenger Agent. The following is an extract from the report just submitted:

Rail motors, costing more from $8,000 to $10,000 each, have been introduced to a greater or less extent by all principal railways of England; also by several on the Continent, as follows: In England, Great Western Ry., London & North Western Ry., London, Brighton & South Coast Ry., London & South Western Ry., Great Central Ry. On the Continent, German Government Rys. (Saxony), Italian State Rys., Paris, Lyons & Mediterranean Ry., Paris & Orleans Ry.

In some cases these rail motors have entirely displaced the steam passenger service on branch lines, but they are generally being used for supplementary service in connection with other trains.

The rail motor car is in charge of a guard, who issues tickets and collects fares, besides performing necessary duties in connection with the handling of luggage and parcels. He also keeps the necessary train records. The car is equipped with a small compartment on the rear platform in which is placed a throttle connection with the boiler, the necessary brake apparatus and whistle, which permits it to be operated from either end, making it unnecessary at any time to turn the car. The design and construction of the car is such as to make it unsuitable for shifting purposes. On lines where motor cars are operated, the freight train service is performed by a regular locomotive.

It appears that where rail motor service has been established travel has increased to a considerable extent. Within itself, the service is not remunerative, but the expense would seem to be warranted when its value as a feeder in creating additional long-distance travel from the main line steam trains is considered.

Operating officials of roads on which this character of service has been established were rather enthusiastic as to its possibilities. The mechanical officials, however, were not favorable to it. It was admitted that there is a slight saving in fuel, but it is claimed that this is more than offset by the increased cost of maintenance and the loss of service while undergoing repairs.

On the Continent, while this service is in actual operation to a limited extent in Germany, France and Italy, railway officials still consider it to be in an experimental stage.

We inspected the Great Western Ry. motor service from Southall to Ealing, both stations being suburban to London. The speed ranged from 20 to 45 miles an hour. The driver said the car was capable of 50 miles per hour. The car ran smoothly, without noticeable vibration, and had been in successful operation for three years. The London & Northwestern operates a rail motor line on its Oxford branch from Bicester to Oxford. The London, Brighton & South Coast has two gasoline motors in service at Brighton. Each car is equipped with two 30-HP. Daimler motors suspended from the frame. Noise and vibration were noticeable while these cars were standing with the motors running. There was also a very disagreeable odor from the gasoline.

The London, Brighton & South Coast Ry. has small detachable steam locomotives at Brighton, which are attached to trailers. Local officials said this service was more satisfactory than by the gasoline cars. The London & South Western Ry. has 14 steam rail motors from its Marylebone Station, London.

German railways, under government management, have been experimenting with rail motors two years, using for purposes of comparison a Serpollet car (steam, with coal fuel), a Milnes-Daimler car (gasoline), and an Accumulator car (storage battery), also a small locomotive and coach. We were told that the experiment so far showed the steam locomotive and coach to be the most economical and successful.

With the benefit of this experience the committee is of opinion that the installation of self-contained motor cars for passenger service on certain branch lines largely depends upon the gradients, the possibilities for increased travel and the possible saving from a reduction in the train crews. A small tank locomotive and car, equipped for operation in either direction without turning, commends itself as the most elastic adaptation of the rail motor which came under our observation, and appears to be in the line of future development abroad.

EXPERIENCE OF ENGLISH RAILWAYS WITH AUTOMOBILE COACH LINES.

Automobile coach lines, as tributary to railway service, have been investigated by a committee of Pennsylvania R. R. officials which went to Europe to study foreign practice in the operation of such lines by railway companies. The committee, of which Mr. C. M. Sheaffer, Superintendent of Passenger Transportation, was chairman, found these automobile coach lines even under the favorable conditions of Great Britain to be of doubtful success, and reported that the poor roads, severe climate and sparsely settled country here would all militate against their success in this country. The following are extracts from the report:

The road motors for passenger service are simply automobile omnibuses of various types, the cost varying from $3,000 to $5,000, some of them having double decks, and in many cases small compartments for the accommodation of luggage and parcels. Machines of this character have been introduced to a greater or less extent by the following railways:

London & North Western Ry., Great Western Ry., London & South Western Ry., Great Eastern Ry. and Caledonian Ry.

Frequent road motor service has been established at points where there are villages not located on the railways, but with sufficient population to warrant the service, also from stations on the main line, as well as from the terminus of one branch line to that of another. These motors are operated on advertised schedules, at a maximum speed of 15 miles per hour. The routes covered range from three to twenty miles in length.

The established schedules are maintained with a fair degree of regularity; the service is well patronized, and is appreciated by those depending upon it. However, your Committee failed to find, at any of the places visited, very much enthusiasm expressed in regard to the road motor proposition from a railroad standpoint, some of the railway officials stating that they did not consider this character of service a proper function of a steam railway company. In some cases negotiations were under way with independent automobile omnibus companies to take over and operate the road motor service; and, further, we failed to find any road motors in operation or contemplated in connection with any of the Continental railways.

The Great Western Ry., on account of the numerous small towns and villages adjacent to its lines, is the largest user of road motors, owning 84 machines and operating them on 44 established lines. We inspected the service between Slough and Stoke-Poges, a distance of ten miles the round trip. The car used was equipped with a four-cylinder gasoline engine of the Milnes-Daimler type, and had a carrying capacity of 20 persons. Steam road motors have been tried on this line, but were unsuccessful on account of boiler troubles, and they have been abandoned. The London & South Western Ry. has four steam road motors of the Clarkson type, which are considered quite unsatisfactory.

The Great Eastern Ry. has 18 motors—four Daimler, two Wolsely, two Thornycroft, and ten built by themselves. The cars have double decks and each seats 38 persons. The Caledonian Ry. of Scotland has two road motors in service a few miles from Glasgow, between Clarkston and Eaglesham, a distance of eight miles.

It was noted that wherever steam has been used for the operation of road motors they have proven unsatisfactory, and that gasoline machines are the most successfully operated, those of the Milnes-Daimler type predominating.

It is the opinion of your Committee that the establishment of this character of service as an adjunct to our railway passenger business is not worthy of any serious consideration at this time, and it is our judgment that the same cannot be successfully or profitably operated, on account of the general bad condition of the roads, severe climate and the territory not at present covered by trolley lines being so sparsely settled as to make such service unnecessary and unwarranted.

THREE TALL STEEL SMOKESTACKS at the plant of the Western Steel Car & Foundry Co., at Hegewisch, Ill., were blown down during a heavy wind storm on March 27. One of these was 350 ft. high; the other two were 200 ft. high.

REPORT ON THE WATER SUPPLY OF BRISBANE QUEENSLAND.

As a result of a visit to Brisbane, Queensland, on behalf of the Board of Water-Works of that city, a progress report on an additional water supply for Brisbane has been made by Mr. Allen Hazen, M. Am. Soc. C. E., of Hazen & Whipple, 220 Broadway, New York City. Mr. Hazen recommends that the supply be increased by the construction of a storage reservoir on a tributary of the Brisbane River, and that two purification plants be built, one an intermittent sand filter plant and the other a plant combining coagulation, sedimentation and mechanical filtration; aeration would be included in each case. In addition to the improvements mentioned, various pipe lines, a dam and pumping station would be required. The estimated cost of the proposed works complete would be about $2,700,000, somewhat less than half of which need be expended at the outset.

At the present time, an average daily amount of about 5,600,000 U. S. gals. are supplied daily to some 100,000 people out of a total of 130,000 living in the Brisbane district. Every house in Brisbane is now provided with a water tank of corrugated galvanized iron in which the roof water, which is preferred to the public supply, is collected. Analyses show that this water contains something like 1 grain of zinc per gallon, but no harmful results therefrom have been noticed. It is estimated that within 15 years an average daily supply of some 14,500,000 U. S. gals. will be required, with a maximum of some 17,000,000 gals. Of this quantity about 2,500,000 gals. may be obtained from two small drainage areas known as Enoggera and Gold Creek, leaving the balance to be drawn from the Brisbane River.

The water from the two small drainage areas is soft and free from turbidity, but is colored somewhat by fallen leaves and other organic matter. Considerable trouble is caused by microscopic and other organisms, which give rise to objectionable tastes and odors. The water is deficient in dissolved oxygen and attacks the iron pipes conveying it to such an extent that it is necessary to scrape these at intervals. The water from the Brisbane River does not cause such deposits in the mains as to make scraping necessary. In times of flood, however, the Brisbane River water is turbid. In 1906 the maximum turbidity was 1,000 parts per 1,000,000. For 20 days the turbidity was more than 200 parts, while the general average for the year averaged 60 parts per 1,000,000. The report states that "the turbidity is of a finely divided clayey nature, not easily removed by settling or filtering. There is comparatively little pollution on any of the drainage areas. The most important constituents of the various waters mentioned are shown in the accompany table, the last column of which also gives figures for water from Stradbroke Island, a source of supply which has been much discussed, but which was dismissed by Mr. Hazen because the necessary treatment would be altogether too difficult and expensive.

ANALYSES OF SOURCES OF WATER SUPPLY FOR BRISBANE, QUEENSLAND.
(Parts per 1,000,000.)

	Brisbane River.	Gold Creek.	Enoggera.	Stradbroke Island.
Incrustants (permanent hardness)	16	1	2	18
Alkalinity (temporary hardness)	99	37	32	4
Total hardness	115	38	34	22
Chlorine	59	28	32	38
Iron	1.2	0.5	0.4	61
Albuminoid ammonia	0.196	0.238	0.290	0.206
Free ammonia	0.076	0.061	0.043	0.199

Water from the Enoggera drainage area (12.9 sq. mi.) is impounded in a reservoir of 1,200,000,000 U. S. gals. capacity, only half of which is at sufficient elevation to be of use. Experiments conducted during the past three years indicate that this water could be advantageously treated by means of intermittent filtration through relatively coarse material. Mr. Hazen suggests a rate of 6,000,000 U. S. gals. per day.

The water falling on 3.87 sq. mi. of Gold Creek drainage area is impounded in a reservoir of about 500,000,000 U. S. gals. capacity. This

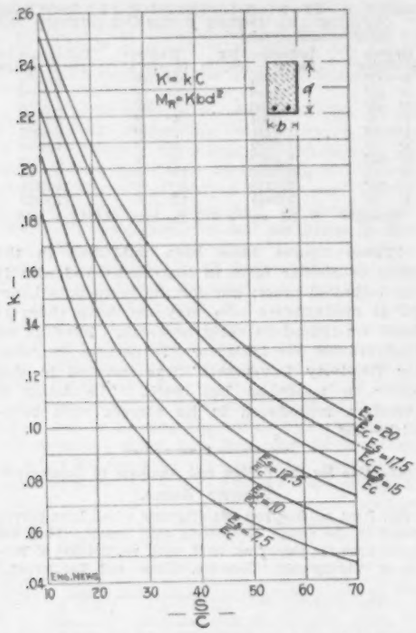


Fig. 2. Diagram Giving Moment-Factor k for Different Values of $\frac{E_s}{E_c}$ and $\frac{S}{C}$.

Formula, $k = \frac{1}{2}\left[\frac{1}{1+\frac{S}{C}\frac{E_c}{E_s}}\right]\left[1-\frac{1}{3\left(1+\frac{S}{C}\frac{E_c}{E_s}\right)}\right]$

Then from Fig. 1 we find p = .0063, and from Fig. 2 k = 0.153.

K = kC = 500 × 0.153 = 76.5, say 77.

$M_r = 77bd^2$.

That is, using .63% steel, when the steel is stressed to 14,000 lbs. per sq. in. and the concrete to 500 lbs. per sq. in., the resisting moment in inch-pounds, M_r, of any beam is $77bd^2$.

Very truly yours, W. H. Kniskern.

707 Heist Bldg., Kansas City, Mo., March 12, 1907.

The Hatchet Planimeter and "Tractrigraph."

Sir: I have read with great interest the article of Mr. A. L. Menzin about his "Tractrigraph" in your issue of Aug. 9, 1906. Instead of his pencil I should prefer putting a piece of blue copying paper, or carbon paper, under the hatchet of my planimeter, and thus let the hatchet draw the tractrix. I think Mr. Menzin has been too severe against my poor instrument, at least I had believed hitherto that it worked quite as well as the hundreds of improvements it has suffered in different countries, when the hints given were followed; and I should be very obliged if you would tell your readers this and give them the hints appended below. The analysis is perhaps too hard for your common readers; but perhaps it might interest yourself to know it, therefore I take the liberty to enclose it in French.

Yours truly, H. Prytz,
Lieutenant-Colonel.

Kongensvej G. F., Copenhagen, Denmark., Jan. 11, 1907.

(Translated from the French.)

THE PRYTZ PLANIMETER 0.25-m.

The area of the figure shown in the sketch below, in square meters, equals ½ C D, or, more accurately, ½ (C D + H K). The mean height equals A B + C D, B C being the base.

A is the initial point, central to the figure; A C the first position of the instrument; A F B′ G C′ F A the path of the tracer point; C M N D the invisible path of the hatchet edge; A H the position after having turned the figure 180°.

The degree of approximation is less than one-half of one per cent. when the dimensions of the figure are not much greater than 0.1 m.

The distance between the tracer-point and the hatchet should be so adjusted that the area of a circle of radius 0.0356 m. is measured correctly.

The differential equation

$$dy = dx_1 + dx_2 \cos y + dx_3 \sin y$$

multiplied by

$$e^{-x_3}(1 + \tan^2 \tfrac{1}{2} y)$$

becomes

$$2e^{-x_3} d\tan \tfrac{1}{2} y + 2\tan \tfrac{1}{2} y\, de^{-x_3} = dx_1 e^{-x_3}(1+\tan^2 \tfrac{1}{2} y) + dx_2 e^{-x_3}(1-\tan^2 \tfrac{1}{2} y) = 2d(e^{-x_3}\tan \tfrac{1}{2} y)$$

from which, if

$$\tan \tfrac{1}{2} y = e^{x_3}\tan \tfrac{1}{2} z$$

$$2d\tan \tfrac{1}{2} z = dx_1(e^{x_3}\tan^2 \tfrac{1}{2} z + e^{-x_3}) - dx_2(e^{x_3}\tan^2 \tfrac{1}{2} z - e^{-x_3})$$

multiplying by

$$2\cos^2 \tfrac{1}{2} z$$

$$2\,dz = [dx_1(e^{x_3}+e^{-x_3}) - dx_2(e^{x_3}-e^{-x_3})] - [dx_1(e^{x_3}-e^{-x_3}) - dx_2(e^{x_3}+e^{-x_3})]\cos z$$

or

$$2\,dz = 2\,dx_4 - 2\,dx_5 \cos z$$

When

$$dx_1 = dx_2 = 0$$

$$\int_{x_3,y}^{0,z} d(e^{-x_3}\tan \tfrac{1}{2} y) = 0 = \tan\frac{1}{2} z - e^{-x_3}\tan\frac{1}{2} y$$

which gives

$$\tan\frac{1}{2} y = e^{x_3}\tan\frac{1}{2} z$$

as a check.

A figure in polar co-ordinates r and v gives for the motion of the planimeter p,

$$du = dv + dv\, r\cos u + dr \sin u$$

u being the angle between p and r. Since the length of p is unity, and if p is carried along r to the initial point, dv = o during this movement, and, calling y the angle between p and the axis,

$$2\,dy = dv\,[2 - e^r - e^{-r} + r(e^r - e^{-r})] + dv\,[e^r - e^{-r} - r(e^r + e^{-r})](\cos v \cos y + \sin v \sin y)$$

$$2\,dy = 2\,dx_1 + 2\,dx_2 \cos y + 2\,dx_3 \sin y$$

If

$$\tan\frac{1}{2} y = e^{x_3}\tan\frac{1}{2} z,$$

$$2\,dz = [dx_1(e^{x_3}+e^{-x_3}) - dx_2(e^{x_3}-e^{-x_3})] - [dx_1(e^{x_3}-e^{-x_3}) - dx_2(e^{x_3}+e^{-x_3})]\cos z$$

$$2\,dz = 2\,dx_4 - 2\,dx_5 \cos z$$

From this, if

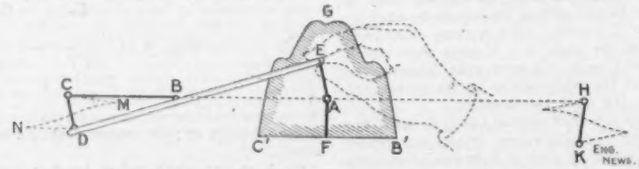
$$\tan\frac{1}{2}\left(90 + z\right) = e^{-x_5}\tan\frac{1}{2}\left(90 + x\right),$$

$$2\,dx = dx_4(e^{x_5}+e^{-x_5}) - dx_4(e^{x_5}-e^{-x_5})]\sin x$$

Developing in series will give the following:

$$dx_1 = dv\left(-\frac{1}{2}r^2 - \frac{1}{24}r^4 - \frac{1}{720}r^6 + r^2 + \frac{1}{6}r^4 - \frac{1}{120}r^6\right) = dA\left(1 + \frac{1}{4}r^2 + \frac{1}{72}r^4\right)$$

dA being equal to $\frac{1}{2} r^2\, dv$.



$$dx_2 = -dA\left(1 + \frac{1}{10}r^2\right)\frac{2}{3} r\cos v$$

$$dx_3 = -dA\left(1 + \frac{1}{10}r^2\right)\frac{2}{3} r\sin v$$

$$x_2 = -t_1 A \qquad x_3 = -t_2 A$$

where t_1 and t_2 are the rectangular co-ordinates of the center of gravity of A.

$$dx_4 = dA\left(1 + \frac{1}{4}r^2 + \frac{1}{72}r^4 - \frac{2}{3} r\cos v\, t_2 A\right)$$

$$dx_5 = -dx_2 \qquad x_5 = t_1 A$$

$$dx = dA\left(1 + \frac{1}{4}r^2 + \frac{1}{72}r^4 - \frac{2}{3} r\cos v\, t_2 A\right)$$

When r = 0.2, x = 1.01 A; and if p = 1.005 and c = 2 p sin ½ x, c = 1.005 A.

Following with the tracer the path indicated by the analysis brings it to the center of gravity. By turning the figure through 180° and retracing, r is changed to −r, and all the odd powers disappear in the mean of the two results. Thus, the same degree of approximation is secured if the initial point is not far removed from the center of gravity.

ACTION OF THE GRAND JURY ON THE NEW YORK CENTRAL WRECK AT WOODLAWN.

The New York Central wreck of Feb. 14 last has been investigated by a Grand Jury, and on March 27th it presented indictments for criminal carelessness or manslaughter in the second degree against the railroad company and two of its principal officials—A. H. Smith, Vice-President and General Manager, and Ira A. McCormack, General Superintendent. The statutory penalty for the crime is imprisonment for not more than 15 years or a fine of not more than $1,000, or both, and in the case of the corporation a fine of not over $5,000.

Accompanying the indictments was a presentment reading as follows:

We do not feel that our duty in this matter is completed without calling to the attention of the proper state authorities certain facts discovered in our inquiry.

The wrecked train left the track at the middle of a curve under the Woodlawn Bridge, the immediate cause being the spreading of a rail on the outer edge of the curve, following the shearing of the spikes on the outside of said rail.

In the morning of the 16th of February the engineer of an electric locomotive train passing around the said curve at a speed of about sixty miles an hour noticed a roughness of track at the point where the rail subsequently spread, sufficient to cause him to report it. An ordinary inspection by track walkers later in the day failed to locate the defect. Subsequent trains passed over the said point of track at normal speeds and no roughness was observed. No subsequent train seems to have exceeded a speed of fifty miles an hour at that point until the Brewster express arrived.

The fatal train was traveling at a speed which calculations by the experts from the company which made the locomotives, based on the distance required to bring the locomotive to a standstill, show to have been at least sixty miles an hour, and which has been estimated by competent observers as high as seventy miles.

After more than a month of careful investigation by experts from the New York Central & Hudson River Railroad and other companies, no defect in roadbed or rolling stock has been discovered which could have caused a wreck at normal speed. The evidence leaves no doubt that the disaster was directly due to some combination of circumstances developed and made disastrous by excessive and abnormal speed.

The curve in question was constructed and safe for a normal speed of about forty-six miles an hour. The company had made no calculation to ascertain, and had no definite knowledge of, how much higher speed could be attained without passing the limits of safety. There were no rules in existence to limit trains to the speed known to be normal and safe. Instead, reliance was placed on the judgment of engineers not to exceed safe speeds.

This, it is claimed, has been the best railroading practice for years. With steam locomotives an experienced engineer could easily estimate his speed, and readily feel when he was going around a curve faster than the normal or so-called equilibrium speed.

The safety of this practice depends manifestly upon having trained and experienced engineers. The new electric locomotives have a much lower center of gravity and run with greater smoothness than the steam locomotives. On this account men not experienced with them tend almost invariably to underestimate their speed, and their action at excessive speed on curves is much less noticeable. They are capable of drawing trains at a speed highly dangerous on the said curve.

If the question of safety in speed was to be left as before to the engineers, it was essential that such engineers should have experience with their engines sufficient to train them to form a competent judgment.

Prior to the installation of a fast passenger electric locomotive service between New York and Wakefield, but one experimental or dummy train was run over the route on schedule. With the exception of the engineer of that train, it seems that none of the engineers who were to operate the new locomotives had been over the route on schedule time in an electric locomotive before being put in charge of a train required to run on schedule time and carrying passengers.

The course of instruction for such engineers had required only four days' practice on a trial track about 2½ miles in length.

Many of the engineers had apparently never ridden on an electric locomotive at a speed even approximating that required by the schedule. While all of them had probably had experience with steam locomotives, they were put in charge of fast trains carrying passengers drawn by electric locomotives at a time when they knew nothing, by experience, of the speed capacity of such locomotives.

The engineer of the wrecked train had not received sufficient instruction to enable him to form a judgment of any value as to the speed at which he was running

is being erected in its open position and does not interfere with or delay either the railroad or vessel traffic through the old swing bridge.

The movable span of this bridge is 230 ft. long, c. to c. of bearings. It is the longest single-leaf bascule bridge yet constructed, and is only exceeded in length of span by the double-leaf Scherzer Rolling Lift Bridge in operation across the Chicago River at the entrance to the Grand Central Station, constructed in 1900, which is 275 ft. c. to c. of bearings.

A STEAM MOTOR CAR will shortly be placed in service by the Chicago, Rock Island & Pacific Ry. The car body is divided into a main compartment, smoking compartment, baggage room and motorman's compartment. The main compartment will seat 32 people, while the smoking compartment will seat 16. The car is built according to the designs of Ganz & Co., Austria. The motorman's compartment contains a Ganz steam generator capable of developing a maximum of 120 HP., coke being used for fuel. The coke bunker is supported by the front end sill and will carry coke sufficient for a continuous run of 50 miles. A Ganz compound steam motor is mounted on the forward truck, driving on the rear axle. The motor is steam jacketed and entirely enclosed, splash lubrication being used. Superheated steam is supplied to it at 270 lbs. pressure. The normal speed of the motor is 600 r. p. m., but it will work satisfactorily up to a speed of 900 r. p. m. Two steel tanks with a total capacity of 600 gals. are suspended from the underframe of the car, and carry enough feed water to supply the boiler for a continuous run of 60 miles.

The car body is of steel construction, the interior finish being quartered oak. The vertical load of the car is carried by the sides, which form deep girders, while the buffing strains are taken care of by longitudinal center sills. The total weight of the car when loaded is 36 tons. It is designed for a speed of 35 miles per hour on level track, or if drawing a trailer at 30 miles per hour, and is fitted with Westinghouse automatic air brakes and axle driven type compressor.

The car was built by the Railway Auto Car Co., of New York City, which controls the American patents and rights of manufacture for the Ganz system, and to whom we are indebted for the above information. The principal dimensions of the car are as follows:

Total length car over end sills	54 ft. 10¾ ins.
Wheel diameter	36 ins.
Wheel base (motor bogie)	8 ft. 3 ins.
Wheel base (trailing bogie)	8 ft.
Total wheel base	40 ft. 8½ ins.
Total weight (loaded)	36 tons

A THREE-TRACK TURNTABLE has been installed at the 14th St. ferry terminal at Hoboken, N. J., for turning electric cars. The object of the arrangement is to secure rapidity of operation during the rush hours. One track leads to the turntable, and two outgoing tracks diverge just at the edge of the pit, the tracks being so arranged that when a car has passed off another can be run on the table while it remains in the same position. The table has then to be turned through an arc of only 120° to bring this car in line with the outgoing track. It is 32 ft. in diameter, and is driven by an electric motor; a car can be put on the table, turned to the other track and run off in about 20 seconds. The turntable was built by the American Bridge Co., of New York.

AN OVAL ROUNDHOUSE with 51 engine stalls and three entrance tracks, has been built by the Chicago & Western Indiana Ry. at 49th St., Chicago, in connection with other terminal improvements. It will be used for the accommodation of the engines of the several railways entering Chicago over this line. The shape is due to right-of-way limitations. The building is about 390 x 425 ft., with a width of 95 ft. in the semicircular ends, and 89 ft. in the sides. The building has an outside brick wall, 23 ft. high, while the inner side has timber posts 31 ft. high, with wooden rolling shutters and doors. The roof timbers are supported by the walls and three rows of intermediate timber posts. The smoke-jacks are of wood, lined on the inside with plaster on expanded metal; they are 15 ft. 8 ins. x 4 ft. 2 ins. at the bottom, and taper to a square section 30 x 30 ins. rising through the roof. Raised ventilators are placed between the smoke-jacks. The building and the pits are heated by exhaust steam, the pipes being laid in recesses in the walls of the pits, which are of concrete, with side drains. The steam pipes are laid in a subway from the new power-house, this subway also containing the condensation return pipes, high-pressure steam pipes, feed-water pipes, water service pipes and compressed air pipes. The turntable is 88 ft. diameter, and is operated by a compressed air motor.

A LOW DAM ACROSS THE SUSQUEHANNA RIVER is proposed by the City of Harrisburg. The project is a part of the comprehensive plan of municipal improvement authorized by popular vote in 1902. The object of the dam is to slightly raise the river level so as to submerge sewer outlets and prevent general unsightliness of the river banks at low water. The dam would be of reinforced concrete, and its estimated cost is $65,000. The necessary legal notice prior to the introduction of the bill in the State legislature authorizing the construction of the dam has been given.

A DAM ACROSS THE CONNECTICUT RIVER is to be built between Hinsdale, N. H., and Vernon, Vt. The dam, which is to be built of reinforced concrete, founded on the solid rock-bed of the river, will divert a 26-ft. head of water into a canal and thence into a large electric power station at Hinsdale. The drainage area covered is approximately 6,300 sq. miles and a development of 12,000 HP. per 10-hour day is expected. On account of the annual log drive down the river a roll-way will have to be provided either over the dam or through the canal.

AN EARTH DAM 82 ft. high is being built by the U. S. Reclamation Service as a part of the Okanogan Irrigation Project, Washington. Construction is being carried out by the Service direct, owing to the fact that no satisfactory bids were received for constructing the dam by contract. The dam must be built between two flood periods and it is hoped that it will be practically finished before the end of this year. Mr. D. C. Henny, of Portland, Ore., is Supervising Engineer for Washington, Oregon and a portion of California.

A TRUNK SEWER TO LAKE ONTARIO has been proposed for the city of Rochester, N. Y., by Mr. Emil Kuichling, M. Am. Soc. C. E., and his proposal has been endorsed by Messrs. G. H. Benzenberg and Rudolph Hering, M.'s Am. Soc. C. E. The sewer would divert from the Genesee River the sewage now discharged into that stream by the East Side Trunk Sewer, and, eventually, the proposition is to connect the other sewer outlets with the proposed trunk sewer extension. The outlet into Lake Ontario would be submerged for 7,000 ft. or more and apparently would terminate in some 45 ft. of water. Mr. Kuichling's report is a lengthy one, reviewing in detail various dilution and purification possibilities. The estimated cost of the recommended scheme is $1,194,300, of which only $881,300 need be expended immediately. The scheme before execution must be approved by the Common Council of Rochester and also by the State Commissioner of Health.

AN EXPERIMENTAL WATER FILTRATION PLANT at Washington, D. C., has been constructed adjacent to the slow sand filtration plant which now treats the water of the District of Columbia. The object of the experimental plant, according to a statement submitted to General Mackenzie, Chief of Engineers, U. S. A., by Capt. Spencer Cosby, Engineer in Charge of the Washington Aqueduct, is to test preliminary filtration as a means of reducing the turbidity of the Potomac River water, and also to determine the best method of preliminary filtration. Five cylindrical reinforced concrete filter tanks have been provided; two of these, for preliminary filtration, are 4 ft. in diameter and 10 ft. deep, and three, for slow sand filtration, are 10 ft. in diameter and 9½ ft. deep. There is also a concrete settling basin 10x29 ft. in plan by 6 ft. deep. The preliminary filters are located above the slow sand filters. One of the preliminary filters contains 6 ins. of broken stone and 3 ft. of filter sand, and in general is of the mechanical-filtration type, but no coagulant is used with it. The other preliminary filter is of the Maignen type, and contains 12 ins. of 2-in. to 5-in. cobblestone, 4 ft. of coke, and some 2 ft. of sponge clippings. Upward filtration will be used in this filter. The settling basin will be used in connection with the third slow sand filter. At times of high turbidity, sulphate of alumina will be used as a coagulant in connection with this basin.

A WATER POLLUTION SUIT has been brought against The Consumers' Gas & Fuel Co., of Atlantic City by the New Jersey State Sewerage Commission. The Commission ordered the company to stop discharging waste oil and tar into the Thoroughfare (tidal water) some time ago, and this order not having been obeyed, the Commission has asked the Court of Chancery to restrain the company from further pollution.

THE TOLEDO FILTRATION CONTRACT, awarded by the city of Toledo, Ohio, some time ago, has been declared valid by the Ohio State Supreme Court. The contract provided for a mechanical filter plant, to be constructed by the Norwood Engineering Co., of Florence, Mass.

LOS ANGELES AQUEDUCT CONSTRUCTION MATTERS will be aided by two bills that have just been enacted by the California legislature and approved by the Governor. One of them authorizes any municipality in the state to construct, maintain and operate roads, railroads, telephone lines, etc., either within or without its own boundaries, for use in constructing public works. This bill is designed to enable Los Angeles to build a railway up the Owens River Valley. The other bill authorizes the city to issue bonds for the aqueduct in $5,000,000 installments.

PRELIMINARY WATER FILTERS FOR ALBANY, N. Y., are to be installed. According to a statement by Mr. Wallace Greenalch, Superintendent of the Water Bureau, plans and specifications have been prepared for 16 of these filters, 18 x 54 ft. in plan, giving an effective filtering area of 810 sq. ft. each and a rated daily capacity of from 24,000,000 to 30,000,000 gals. The filters will be built along the north side of the present sedimentation basin. A 30-in. centrifugal pump of 30,000,000 gals. daily capacity will lift water 9 ft. from the settling basins to the preliminary filters. A 15-in. centrifugal pump of 10,000,000 gals. capacity will be used to provide water to wash the filters by reverse flow. An 18-in. centrifugal pump of 16,000,000 gals. capacity will be added to the present pumping station. Reinforced concrete will be used for the construction of the preliminary filters. The water from the preliminary filters will flow by gravity to the present slow sand filters. The latter, it is expected, can be operated at double their present capacity when receiving the water that has been subjected to preliminary treatment. A bond issue of $400,000 has been authorized for the work. The contract for the centrifugal pumps and the engines to drive them has already been awarded, and it is expected that the other contracts will soon be advertised.

A NEW ELECTRICAL POWER PLANT is now in course of construction to supply the city of Pachuca, Mexico. This new plant, known as the Elba Generating Station, is driven by the waters of the drainage canal from Mexico City, some distance upstream from the old plant, called the Juando Station. At the latter, there is in operation approximately 3,000 HP., comprising six 375-KW. Westinghouse generators supplying the energy at 440 volts, which voltage is raised to approximately 25,000 volts, 3-phase, by means of various banks of large transformers. The voltage is reduced to 2,200 volts for general distribution in the city of Pachuca. The Elba plant will be equipped with four 1,540-KW. generators, generating current at 2,200 volts and driven by turbines. The voltage of the generators is raised to approximately 25,000 volts by means of nine 540-KW. transformers, and the energy is transmitted, at 3-phase, to the Juando plant, where it is connected in multiple with the Juando circuits to Pachuca. A double pole line obviates the possibility of a shut down, which might occur on either of the circuits.

THE COST OF DIAMOND DRILLING varies within wide limits, depending on class of substance drilled, labor, location, etc. According to "Mine and Quarry" a careful record of cost of diamond drilling by a Michigan iron mining company gave the price of $1.50 to $2 per foot. A Western coal company places the cost of its drillings at $1 per foot or less. Drillings in the Lake Superior iron country, aggregating over 11,000 ft., showed costs of from $1.63 to $2.65 per foot. A Mexican copper mine places the cost of drilling 4,160 ft. at $2.22 per foot, of which $1.03 was for "black diamonds" or carbon. The cost of carbon for the holes drilled by the Western coal company was 19 cts., while for the Lake Superior drilling it amounted to $1 per foot. Drilling in the copper country of southeastern Arizona cost $1.73 per foot, of which 38 cts. was for carbon. The cost of coal prospecting in several states is reported as follows: Colorado, $1.65 per foot; Tennessee, $1.26; Indian Territory, $1.18; West Virginia, $1.13 to $1.50.

The average cost of drilling 20 different holes ranging in depth of from 110 to 1,100 ft., through jasper marble and iron slate, is given by the "Engineering and Mining Journal" as $3.14 per foot, 22% of this cost being for carbon, 39% for labor, and the rest for fuel, repairs, supplies, etc. Another series of 16 holes, ranging in depth of from 94 to 380 ft., with an average of 314 ft., showed an average cost of $2.70 per foot, 13% being for carbons and 38% for labor. The cost of drilling soft schist rock was $1 per foot, of which 30% was for diamonds and 66% for labor. The average cost of drilling in the mines of the British Columbia Copper Co., Greenwood, B. C., was given by Mr. Frederick Keffer in a recent address before the Canadian Mining Institute as $2.15 per foot, and the average cost for diamonds as $1.083 per foot.

PERSONALS.

Mr. Bayard G. Eckard, Superintendent of the Municipal Electric Light Plant of Easton, Pa., has resigned.

Mr. R. C. Thurston has been appointed Supervisor of Electric Service for the Erie R. R., at Avon, N. Y.

Mr. Alexander Robertson, General Manager of the Western Maryland R. R., has been made Vice-President.

Mr. William P. Hubbard has resigned as President and Director of the Pittsburg, Wheeling & Kentucky R. R.

water could be advantageously treated by intermittent filtration, also, but as no good site is available, and connection can readily be made with the Brisbane River supply, it is suggested that the latter be done. It is interesting to note in passing that copper sulphate has been used in this reservoir with success.

About 60% of the water now supplied to Brisbane is taken from the Brisbane River. The river has a drainage area of about 4,000 sq. mi., which in general is hilly and woody and has upon it only a small population. On account of the sediment carried by the river when in flood, and the consequent likelihood that a reservoir on the river would fill with sediment, storage on a tributary rather than on the main stream is recommended to make up a deficiency in the dry-weather flow. After the water is brought to the site of the proposed purification works it would first pass through an aerating fountain, then receive a coagulant and afterwards be given six hours of sedimentation. It would then pass through mechanical filters similar to those at Watertown, N. Y., be again aerated, and finally would go to a covered pure water reservoir holding about six hours' supply.

Mr. John Kent is engineer of the Brisbane Board of Water-Works, and assisted Mr. Hazen with material and estimates for use in making his report. Acknowledgment is also given by Mr. Hazen to Mr. H. W. Parkinson, who made "most of the surveys and special investigations connected with the proposed new sources of supply," and to Mr. H. Wasteneys, Chemist of the Board, who "conducted the experiments upon water purification, and has examined the waters and sands under consideration." Indebtedness is also expressed to Mr. J. B. Henderson, M. Am. Soc. C. E., for various reports upon the Brisbane River supply, and to Mr. George Phillips, C. E., for information on the Stradbroke Island proposition. A final report will be made by Mr. Hazen after he receives the results of further surveys.

A METHOD OF CONSTRUCTING AN ELLIPSE AND MEASURING THE CURVED LENGTH.

By FREDERIC R. HONEY,* Ph. B.

Some time ago the writer devised a simple method of drawing an ellipse, with very close approximation, by means of eight circular arcs.† This method lends itself very well to an equally simple graphical method of measuring the curved length of the ellipse, as described in the following. The method of drawing an eight-centered ellipse is first described, although it has been published before.

Let *a b*, Fig. 1, be the major axis, and *c d* the semi-minor axis, on which it is desired to construct an ellipse. Draw any two lines *e f* and *e g*, Fig. 2, forming at *e* any angle. From the center *e*, with radii equal respectively to the semi-major and semi-minor axis, draw the arcs *f h* and *k l*. Lay off *h m* equal to one-eighth of *h l*. Join *m k* and draw *f g* and *l n* parallel to it. In Fig. 1 lay off *b o* equal to *e n*, and *d p* equal to *e g*. Also lay off *b r* and *d q*, each equal to one-half the sum of the semi-axes = ½ (a c + c d). From the center *p*, with the radius *p q*, draw the arc *q s*; and from the center *o* with the radius *o r* draw the arc *r s*, intersecting the former at *s*. Draw the lines *p s* and *s o*, and produce them. From the center *p* with the radius *p d* draw the arc *d v* limited by *p s v*. From the center *s* with the radius *s v* draw the arc *v t* limited by *s o t*, and complete the quadrant of the ellipse by drawing the arc *t b* from the center *o*.

The two semi-ellipses in Fig. 4, with semi-minor axes respectively four-fifths and three-fifths of the length of the semi-major axis, have been drawn in this way. The points *b, d, f* and *h*, which divide the semi-major axis into five equal parts, are the base of ordinates *b a, d c, f e* and *h g*, drawn to the auxiliary circle. It is found that the two ellipses drawn divide these ordinates very nearly at their fifth-points; that is to say, the curves so nearly coincide with the true ellipses that they may be accepted as representations of them.

Since these approximated ellipses are composed of circular arcs, they may be measured by the methods applicable to the latter. Huygens' approximation to the length of a circular arc has found its way into our note-books of engineering formulas. It is easily remembered, readily applied, and gives practically an exact result. Thus, its value is apparent to the civil engineer, who is required to determine the measurement of long curves, and to the architect whose work includes the measurement of the soffit of an arch.

Let *a b c*, Fig. 3, be an arc of a circle whose length is required. Bisect it at *b*, and draw the chords *a c*, *a b*, and *b c*. The length of the arc according to this approximation is

$$\frac{8\,a\,b - a\,c}{3}$$

The degree of accuracy obtained is easily tested for an arc subtending any assigned angle. For an arc subtending 30°, *a b* = 2 sin 7½°; and *a c* = 2 sin 15°. Therefore if we call the radius one foot, the formula becomes ⅓ (16 sin 7½° — 2 sin 15°) = 0.523593 ft. The semi-circumference (= π*r*) divided by 6 will give the length of the

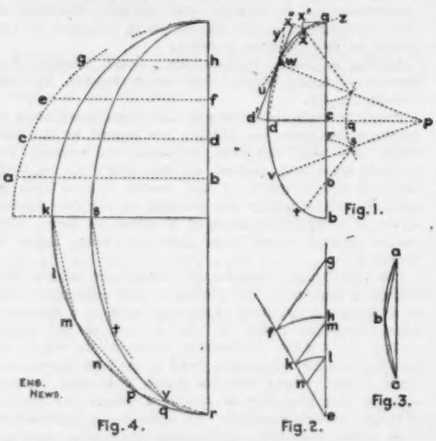


Fig. 4.

Fig. 2.

Fig. 1.

Fig. 3.

arc; and ⅙ × 3.1415926 = 0.523599 ft. The difference between these measurements is 0.523599 — 0.523593 = 0.000006 ft. If we multiply the radius by 10000, the approximate measurement will be 5235.93 ft., or 0.06 ft. short of the true length in a measurement of nearly one mile. This error is only a fraction of an inch. For arcs subtending larger angles, while the error increases rapidly, it yet remains only a very small percentage of the length of the curve. For 60°, ⅓ (16 sin 15° — 2 sin 30°) = 1.0470346, and the difference between this measurement and ⅙π (= 1.0471975) is not quite 20 ins. in an arc nearly two miles in length. Applying the same rule to the measurement of a quadrant, ⅓ (16 sin 22½° — 2 sin 45°) = 1.56597; and the difference between this result and ½π is slightly over 12 ft. in a curve nearly three miles long. Even this last result involves an error which is a small percentage of the length of the arc.

This method is applicable without change to measuring the length of the ellipse drawn by the method before described. Thus: in the outer curve in Fig. 4, bisect arc *k m* at *l*, *m p* at *n* and *p r* at *q*. Then the length of the quadrant is equal to

$$\frac{8\,(k\,l + m\,n + p\,q) - (k\,m + m\,p + p\,r)}{3}$$

As the tests applied above show the method to involve an error which in an arc subtending 30° is exceedingly small, and even on larger angles would not be of sensible amount in a practical example, the length of the ellipse thus measured may be taken as practically exact.

A different method is available for rapid work on the drawing board. It is an application of the well-known method of rectifying an arc on its tangent. In Fig. 1 draw the common tangent to the arcs *d w* and *x w* perpendicular to *p w*. Draw the chords of the arcs *d w*, *x w*, and *x d*, and in each case produce the chord, making the produced part one-half the length of the chord.

From the center *y* with a radius equal to one and one-half times the chord, draw the arc *d' d'* intersecting the tangent *w d'* at *d'*; *w d'* measures the arc *w d*. Similarly from the center *u* with the radius equal to one and one-half times the chord, draw the arc *x x''* intersecting the tangent *w x''* at *x''*. The tangent *d' x''* measures the curve *d w x*. From the center *z*, with the radius *z x* equal to one and one-half times the chord *x x*, draw the arc *x x'* intersecting the tangent *p x'* at *x'*. The sum of the lengths of the tangents *d' x''* and *a x'* gives the total length of the quadrant.

SURPRISE SIGNAL TESTS have been carried on by the Pennsylvania Railroad for the last three months with extremely gratifying results. During this time 97 separate tests have been made upon 2,252 trains, and of that number 97% of the engineers have complied with the rules of the company, while the remaining 3%, who are marked in the official record of the company as deficient, brought their trains to a stop, but not until after passing the signals. The tests are conducted by division officials of the company, who, at unusual times and places, set signals at caution or danger, extinguish signal lights, display fuses, or place torpedoes on the track, with a view to keeping all enginemen constantly on the alert for any and all signals. The records show a constant increase in carefulness, and it is thought that this method is of great use in improving the signal conditions along the road.

FOUR ATTEMPTS TO WRECK PASSENGER TRAINS have occurred lately: Three of these were successful, but no great damage was done to railroad property and no one was killed or seriously injured. Three attempts were made to derail Pennsylvania R. R. trains and one to wreck a train on the Louisiana Southern Ry. In two of the attempts to wreck Pennsylvania flyers, a few miles east of Pittsburg, the fish plates were removed and the rails moved out of line. The train in each case, however, was running slowly, so that the damage was slight. The Pennsylvania R. R. Co. has offered a reward of $2,500 for the arrest and conviction of the persons guilty of wrecking the "Chicago Limited," which was the first train wrecked, as noted in our last issue, a like sum for the arrest and conviction of those guilty of causing the second wreck, to the "Keystone Express," and $500 for information leading to the arrest of the guilty person or persons in either case. The third attempt to wreck a Pennsylvania train was made at Lowellville, Ohio, by placing a telephone pole across the rails and securing its ends with stakes. The obstruction was, however, discovered by the crew of a shifting engine and removed before the approach of a fast train. The wreck in Louisiana was caused by cross-ties, 31 of which had been chained at short intervals to the rails of the Louisiana Southern Ry. south of New Orleans. A local passenger train was derailed. The wrecking of the "Keystone Express" occurred March 27, the attempt to wreck the train at Lowellville, March 30, and the wreck at New Orleans, March 30.

AN OPEN SWITCH ACCIDENT on the Southern Pacific Ry. at Colton, Cal., on March 28 resulted in the death of nearly 25 persons and the injury of 50 more. The accident occurred at the entrance to the yards, nearly a mile from the station. A through transcontinental express train of 14 cars was posted as 8 hours late when the yard foreman went to his dinner and on coming back, the time having elapsed, he concluded the train had passed during his absence, and went to work in a distant part of the yard. The express, however, was later than the time posted and it entered the yard at a speed of 50 miles an hour. At a facing switch the locomotive tipped over on the sharp turnout curve and the train was piled in a wreck, the first four cars taking the brunt of the shock.

THE HUDSON BAY RAILWAY PROJECT will be assisted by the Canadian Government to the extent of the funds arising from the disposal of land pre-emptions in the three prairie provinces which would be chiefly benefited by the proposed railway. A land grant was offered in aid of the construction of this road in 1886, amounting to 6,400 acres per mile in Manitoba and 12,800 acres per mile for construction outside of Manitoba. The proposed aid would be in lieu of this land grant, which has never been taken advantage of.

A VERY LONG BASCULE BRIDGE is being built for the Baltimore & Ohio R. R. at Cleveland, Ohio, by the Scherzer Rolling Lift Bridge Co., of Chicago, Ill., to take the place of a center-pier swing bridge across the old channel of the Cuyahoga River. The new bridge

*Instructor at Trinity College, 778 Broad St., Hartford, Conn.

†Corresponding to five arcs for the half ellipse, as in the five-centered elliptical arch so widely used in masonry bridge construction.—Ed.

Mr. J. R. Lovejoy has been appointed General Manager of Sales Department of the General Electric Co. at Schenectady, N. Y.

Mr. W. J. Haynen has been appointed Master Mechanic of the Mississippi Central R. R., to succeed Mr. R. M. Boldridge, resigned.

Mr. B. F. Beckman has been appointed Superintendent of the St. Louis, El Reno & Western Ry., with headquarters at Fort Smith, Ark.

Mr. Edmund S. Kirby has been appointed General Manager of the Federal Lead Co., Flat River, Mo., to succeed Mr. F. M. Fitzgerald, resigned.

Mr. James Scanlon has been appointed Superintendent of Section No. 2 of the Erie Canal, to succeed Mr. James B. McKain, resigned on account of ill health.

Mr. John C. Reid, General Superintendent of the Great Western Coal & Coke Co., McAlester, Ind. Ter., has been promoted to the position of General Manager.

Mr. William G. Clark has been made Consulting Engineer to the Board of Public Service of Toledo, Ohio, to supervise the construction of the new filter plant.

Mr. F. McDonald, formerly Superintendent of the Commercial Mine, Bingham, Utah, has been appointed Superintendent of the Ohio Copper Co., of the same place.

Mr. W. L. Cumings, Mechanical Engineer of the Bethlehem Steel Co., South Bethlehem, Pa., has accepted a position with the Juragua Iron Co., of Santiago de Cuba.

Mr. Robert H. Ford, Assoc. M. Am. Soc. C. E., has been appointed Principal Assistant Engineer of the Missouri Pacific Ry., to succeed Mr. R. C. St. John, transferred.

Mr. L. F. Champion has been appointed Resident Engineer of the Western Division of the Southern Pacific, at Oakland, Cal., to succeed Mr. R. M. Drake, promoted.

Mr. Jesse P. Wellborn, Vice-President and Sales and Traffic Manager of the Colorado Fuel & Iron Co., of Denver, Colo., has been elected President, to succeed the late Frank J. Hearne.

Mr. Geo. C. Whipple, M. Am. Soc. C. E., 220 Broadway, New York City, has resigned from membership on the Water Pollution Committee of the Merchants' Association of New York City.

Mr. G. F. Hawks, General Superintendent of the Houston & Texas Central R. R., at Houston, Texas, has been appointed General Manager of the El Paso Southwestern Ry., with office at El Paso, Texas.

Mr. W. R. Hudson, Superintendent of the Richmond Division of the Seaboard Air Line Ry., has resigned, to become Superintendent of Terminals of the Southern Ry. at Salisbury, N. C. He is succeeded by Mr. J. H. Witt.

Mr. W. E. Green, Vice-President and General Superintendent of the St. Louis Southwestern Ry., at Tyler, Texas, has been appointed General Manager of the Trinity & Brazos Valley Ry., with office at Fort Worth Texas.

Mr. Herbert B. Walker, Vice-President and General Manager of the Old Dominion Line Steamship Co., has been elected President, to succeed the late W. L. Guillaudeu. Mr. Walker has been connected with the company 24 years.

Mr. W. S. Tinsman has been advanced from Superintendent of the Southwestern District of the Chicago, Rock Island & Pacific Ry., to Assistant General Manager, with office at Chicago, Ill. Mr. A. E. Sweet succeeds him as Superintendent.

Mr. Richard E. Danforth, General Manager of the Rochester Railway Co., has been appointed General Manager of the Street Railway Department of the Public Service Corporation of New Jersey, to succeed Mr. Albert H. Stanley, resigned.

Mr. G. S. Brantingham, Second Vice-President of D. E. Baxter & Co., Railroad Contractors, 27 William St., New York City, and Mr. Charles M. Meeker, 50 Broadway, New York City, have been elected directors of the Lake Superior Southern Ry.

Mr. John P. Wilson has been elected President of the Dover & Philadelphia Navigation Co. Mr. A. B. Magee has been made Vice-President; Mr. Wilbur D. Burton, Secretary and Treasurer. The company will run boats between Dover and Philadelphia.

Mr. J. W. Stewart has resigned as Chief Engineer of the Norfolk & Southern Ry., and his duties have been assumed by Vice-President Chas. O. Haines. Mr. Thomas W. Cothran is Principal Assistant Engineer; Messrs. Wm. P. Marshall and C. C. Fitzgerald, Division Engineers.

Mr. R. W. Hebard, Assistant Engineer, Department of Construction & Engineering, Isthmian Canal Commission, has been promoted to be Resident Engineer. He has been connected with the department since May, 1905, and previous to that was employed by the Chicago, Rock Island & Pacific Ry.

Mr. J. H. Strubel, General Superintendent of the Chicago, Indianapolis & Louisville Ry., has been appointed Assistant General Manager of the Detroit, Toledo & Ironton Ry. and Ann Arbor R. R. Mr. W. G. Wallace, formerly with the Duluth, Missabe & Northern Ry., has been appointed Superintendent of Motive Power.

Mr. James J. Hill, President of the Great Northern Ry., has resigned and has been made Chairman of the Board of Directors. He is in his sixty-ninth year and has been President of the company since Sept. 11, 1889. Mr. Hill is succeeded as President by his son, Mr. Louis W. Hill, who has been First Vice-President of the Great Northern, and Mr. Frank H. McGuigan, late Fourth Vice-President of the Grand Trunk, succeeds Mr. Louis Hill.

Mr. C. A. Alderman, M. Am. Soc. C. E., Chief Engineer of the Cincinnati Northern Traction Co., has resigned, and accepted a position with J. G. White & Co., of New York City. While acting as chief engineer, Mr. Alderman has rebuilt the line between Cincinnati and Dayton, Ohio, and located and built a line from Lima to Leipsic. He was formerly Chief Engineer and Manager of the Great Northern Construction Co.

Mr. J. H. Young, General Manager of the Colorado & Southern Ry. at Denver, Colo., has been appointed General Superintendent of the First District of the Atchison, Topeka & Santa Fe System, with headquarters at Springfield, Ill. Mr. A. J. Sams has been appointed Superintendent of the Western Division, with headquarters at Enid, Okla. Mr. T. B. Coppage, Superintendent of the Gulf, Colorado & Santa Fe Ry. at Temple, Tex., will succeed Mr. Sams as Superintendent of the Frisco System, at Birmingham, Ala.

The following changes have taken place in the personnel of the Reclamation Service: Mr. L. E. Foster has been appointed Superintendent of Irrigation, Carlsbad Project; Mr. F. B. Davis has been appointed Junior Engineer and assigned to the Portland office; Messrs. J. G. Marzel, F. L. Mitchell, H. M. Schilling and Fulton Pace have been appointed Engineering Aids and assigned respectively to the Interstate Canal, the Lower Yellowstone Project, the Truckee-Carson Project and Caldwell, Ind.

Major G. W. Goethals, Chief Engineer of the Isthmian Canal Commission, has been elected President of the Panama Railroad & Steamship Co., to succeed Mr. Theodore P. Shonts, resigned. Mr. E. A. Drake was elected Vice-President; Mr. T. H. Rosebottom, Secretary, and Mr. S. Deming, Treasurer. Majors G. W. Goethals, D. DuB. Gaillard, and W. L. Sibert, Dr. W. C. Gorgas, Mr. Jackson Smith, Rear-Admiral H. H. Rousseau and Ex-Senator J. C. S. Blackburn were added to the directorate.

Mr. S. C. Long, Superintendent of the Pittsburg Division of the Pennsylvania R. R., has been promoted to be General Superintendent of the Western Pennsylvania Division, a new grand division composed of the Pittsburg, West Penn, and Monongahela divisions, and that part of the Allegheny Division between Pittsburg and Kiski Junction. Mr. Robert T. Morrow succeeds Mr. Long as Superintendent of the Pittsburg Division, while Mr. Andrew Keiser succeeds Mr. Morrow as Assistant Superintendent of the West Penn Division. Mr. Daniel C. Stewart has been appointed Assistant Superintendent of the Pittsburg Division, to succeed Mr. Keiser. Mr. George W. Snyder has been appointed Principal Assistant Engineer of the new division, and Mr. David M. Perine, Superintendent of Motive Power. Mr. D. M. Wallis, Master Mechanic of the Baltimore & West Philadelphia shops, succeeds Mr. Perine as Superintendent of the Philadelphia & Erie R. R. and the Northern Central Ry. Mr. W. G. Coughlin has been appointed Superintendent of the Middle and Western Division of the Philadelphia & Erie R. R., to succeed the late Thomas Roberts. Mr. James Buckelew has been made Superintendent of the Allegheny Division; Mr. Herbert A. Jaggard, Superintendent of the Elmira & Canandaigua Division; Mr. A. J. Whitney, Jr., Superintendent of the Delaware Division, and Mr. Charles S. Kirk, Superintendent of the Pennsylvania, New York & Long Island R. R. Mr. Allen B. Cuthbert, Assistant Engineer of the Middle Division, succeeds Mr. Whitney as Principal Assistant Engineer of the Pennsylvania Railroad Division. Mr. Elisha Lee succeeds Mr. Kirk as Principal Assistant Engineer of the Philadelphia, Baltimore & Washington R. R.

Obituary.

Jacob Reese, a pioneer in the steel industry of Pennsylvania, died at his home in Sharon Hill, Philadelphia, Pa., March 26, of apoplexy, aged 82 years.

Edward C. Nichols, Vice-President and General Manager of the South Side Elevated R. R. of Chicago, Ill., died March 28, of pneumonia, aged 37 years.

Hugh F. Magee, a contractor of Taunton, Mass., died March 28. He had done much municipal work for the city, and had also been engaged in railroad building in the Klondike region of Alaska.

John Smith Hoover, a civil engineer in the employ of Solomon-Norcross Co., Civil, Structural and Hydraulic Engineers of Atlanta, Ga., died in that city March 26 of spinal meningitis, aged 37 years. He was a graduate of the Rensselaer Polytechnic Institute of Troy, N. Y., and was formerly County Engineer of Stark County, Ohio.

David Keddie, formerly a prominent builder and contractor of New York City, died at Roselle, N. J., March 30, aged 79 years. He was born at Kirkcaldy, Scotland, and came to the United States in 1847. Mr. Keddie's firm, Gibson & Co., built the original Times Building at 41 Park Row, in 1857, Dr. Parkhurst's old church in Madison Square, the Coal and Iron Exchange, Fort-landt Street, and many other buildings. It is interesting to note that many of the buildings which this company constructed, were largely built of brown stone.

William K. Niver, organizer of W. K. Niver & Co., Coal Dealers, with offices at Boston, Mass., Baltimore, Md., Syracuse and Oswego, N. Y., died at Syracuse March 31, aged 72 years. At an earlier period of his life he was an assistant superintendent for a division of the Delaware, Lackawanna & Western R. R. Later he became Superintendent of the Syracuse, Binghamton & New York R. R., then General Superintendent of the Western Division of the Lehigh Valley R. R. He also acted as Vice-President of the Boston & Maine R. R. for a time.

ENGINEERING SOCIETIES.

COMING MEETINGS.

IOWA ELECTRICAL ASSOCIATION.
April 18-19. Annual Meeting at Clinton, Iowa. Secy., L. P. Spinney, Iowa State College, Ames, Iowa.

THE AMERICAN RAILWAY ASSOCIATION.
April 24. Annual Meeting at Chicago. Secy., W. F. Allen, 24 Park Pl., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 2-4. Annual meeting at Philadelphia, Pa. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 21-24. Annual convention at Philadelphia, Pa. Secy., Richard Moldenke, Watchung, N. J.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22-24. Annual Meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 28-31. Semi-annual Meeting at Indianapolis, Ind. Secy., Mr. Calvin W. Rice, Engineering Societies Bldg., 33 West 39th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 12-14. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN WATER-WORKS ASSOCIATION.
June 17-22. Annual convention at Toronto, Ont. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-20. Annual meeting at Atlantic City, N. J. Secy., P. W. Drew, Wisconsin Central Ry., Milwaukee, Wis.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Niagara Falls, N. Y. Secy., Ralph W. Pope, 29 West 39th St., New York City.

THE MUNICIPAL ENGINEERS OF THE CITY OF New York held their regular monthly meeting in the Engineering Societies Building, March 27, 1907, President Rice in the chair. The paper of the evening was entitled "The Geology of Long Island and Its Practical Relation to Underground Water Supplies," by Mr. A. S. Farmer, Assistant Engineer, Aqueduct Commission. Mr. Farmer's lecture, which was fully illustrated with lantern slides, traced the geological history of the northeastern portion of the United States and particularly of Long Island in its especial relation to the subterranean water conditions now existing. This geological history was followed by descriptions of the various pumping stations on the island and the different methods of pumping.

WASHINGTON ASSOCIATION OF THE MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS. —The annual banquet was held at Rauscher's, corner of Connecticut Avenue and L Street, March 23, at 7.30 p. m. Some 38 members were present, and, after the menu had been disposed of, Mr. F. H. Newell spoke on the "Reclamation Service"; Mr. A. M. Phillips on "The Sewerage System of Washington"; Capt. J. S. Sewell on "Reinforced Concrete Construction and Conflagration Prevention"; Mr. W. H. Wiley on "The Relations of Congress to District Engineering"; Mr. John F. Hayford on "The Relation of Science to Engineering"; Mr. M. O. Leighton on "Opportunities of Engineering", and Mr. W J McGee on "The Inland Waterways Commission and Needed Improvements in Transportation Facilities of the Country." Gen. W. Crozier gave an informal address on "Modern Ordnance," and Mr. H. M. Wilson one on "National Drainage of Swamps and Overflowed Lands."

The organization is governed by a committee of five members, those elected for the ensuing year being: Chairman, Mr. F. H. Newell; Gen. W. Crozier, Mr. F. L. Averill, Mr. C. B. Hunt and Mr. G. R. Putnam.